# THE JOURNAL OF INDUSTRIAL ENGINEERING


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# Our Future With The American Institute Of Industrial Engineers

By E. L. Slagle, *National President A.I.I.E.*

**President Slagle's Acceptance Speech at the Sixth Annual Conference of the American Institute of Industrial Engineers at the Kingsway Hotel St. Louis, Missouri May 14, 1955**

I am here today to express my thanks for the high honor you have bestowed upon me. Further, I wish to assure you that I will do my utmost to merit this honor. The future of the Institute has always been in my thoughts, and we from the West have left no stone unturned in an effort to increase the growth and stature of our regional group. As your National President, I must broaden my horizon and work with continued and increased vigor to establish an organization capable of accepting its proper responsibilities.

You are all well acquainted with our purposes. I am sure you are equally as familiar with our successes. The status our profession enjoys was achieved through the work of a countless number of individuals whose combined efforts have resulted in the hard core of realistic principles which guide us today. To build upon this heritage we must continue to expand both our organization and the scope of its activities. I do not underestimate the magnitude of that job.

The growth of the engineering profession has been truly remarkable. Fifty years ago industry employed one engineer for every 250 employees; today there is an engineer for every 60 employees. The growth and development of industrial engineering has been even more remarkable. Stemming from the original and pioneer work of such individuals as Frederick W. Taylor and the Gilbreths, industrial engineering techniques have today become widely accepted and now constitute a management instrument of real value. In 1900 there was but a handful of industrial engineers. In 1950 there were 46,000 It is estimated that there are currently 52,000. Another indicator of this growth is found in a comparison between the 1940 and the 1950 United States Census Bureau statistics. In these data we find that in the last decade the number of industrial engineers in the United States increased by 376%. This compares with chemical engineering at 168%, metallurgy and mining at 164%, electrical engineering at 68%, civil engineering at 18%, and mechanical engineering at 15%.

This rapid rate of growth is typical for any new commodity or service the acceptance of which is based upon real need. It is generally agreed that the growth of industrial engineering is a natural result of: (1) the industrial revolution, which from a historical point of view, is a rather recent development; and (2) our free enterprise system which allows management only two alternatives: aggressive, efficient management or economic death at the hands of competitors and consumers.

Effectively supplying goods or services begins with an organization. The question, "Why should we organize?" is asked so often that it may be worthwhile to dwell for a moment on the matter. If the people who ask such questions seriously attempted to develop a list of reasons supporting their point of view, they would probably find that there are few, if any, good reasons. I am sure that the value of organization, as such, is not in question. If our ancestors had not found it necessary to establish the original organizations, small tribes and families, we would still live in caves and sally forth, club and rock in hand, looking for food or, perhaps, a wife. The medical and legal associations provide ample proof of the advantages of organization to both society and the profession. Only through such cooperative effort can ethics and principles be established and maintained. Organization provides a voice for the group in its various dealings with other groups in the same general field of endeavor and with representatives of the government; and, further, provides for the communication and exchange of ideas. This, I believe, is enough of the abc's of "why organize?". The reason for the existence of the American Institute of Industrial Engineers should be perfectly obvious.

Before I leave this particular matter, there is another point which should be made. To think only in terms of the immediate benefit which organization will bring to our membership is wrong on two counts: (1) benefit, through improved stature, will not accrue to us for many years; and (2) such benefit should be thought of as a by-product of the desire to do a better job. Organization stems from need—not the need of the group members, but, rather, the need of the people they serve. If we lose sight of this, if we proceed on a self-serving basis, we will no longer progress—or exist as a group.

The American Institute of Industrial Engineers is experiencing a growth rate similar to that of industrial engineering in the United States. Our first chapter was organized in Columbus, Ohio, only 7 years ago by Wyllys G. Stanton and eleven other pioneers of our organization. Thus, in 1948, we had but one chapter, no Journal or News Letter, and but a handful of members. Today we have 48 senior chapters, 25 student chapters, and an excellent Journal and News Letter. In our effort to increase the strength of our membership, we have not confused strength with number of members. It is often painfully difficult to insist upon rigid adherence to our membership qualification requirements. We owe a real vote of thanks to our membership qualification committees for the job they have done and for their continued resistance to pressures. To preclude any feeling of complacency with regard to our growth it is, perhaps, appropriate to call to your attention an uncomfortable fact: the American Institute of Industrial Engineers has as its membership only 8% of the individuals in the United States who earn their living as industrial engineers.

In connection with the quality of our membership, it may be worthwhile to take time to review briefly the matter

of professional registration. Here again, we are frequently asked the question, "Why should I register?", or even, "What is the advantage to me if I register?". And, once again, we find the answer is similar to the one used in reply to questions pertaining to the reason for organization. There is little, if any, immediate advantage to an individual except in isolated cases. The benefit is long-range in nature and will accrue to the industrial engineering profession as a whole many years hence. Real progress is not made by persons with a short-range and self-serving point of view. The Professional Registration Committee is not attempting to create pressures to the end that all members will register. This committee does, however, operate on the basis that it would be remiss if it did not point to the reasons for registration and encourage our members to join the ranks of licensed engineers. The control which each of the 48 states and the various territories established was obviously based upon some basic need of the public. A look at the ever-increasing numbers of licensed engineers can lead us to but one conclusion: licensing will some day be a basic requirement for individuals wishing to practice engineering.

In February, 1955, the Professional Registration Committee made a survey of the membership to determine our registration status. You may be interested in some of the results of that survey. It was found that: (1) just a trifle over 13% of our membership is registered; (2) less than 2% of our membership is registered in 2 or more states; (3) 57% of the membership responded by returning a completed questionnaire; and (4) approximately 29% of our membership desires help by way of additional information leading to eventual registration. It is planned that surveys of this type will be made from time to time so that we may be better informed regarding the composition of the membership, and so that we may better plan our efforts. This initial survey clearly indicates that progress has been made but that there is much to be done.

Prior to outlining a program designed to cope with current and general problems of the A.I.I.E., a close look at what we have to work with is in order.

First, we have a very excellent national organization which was assembled and given direction by my predecessors. Don Malcolm did a most noteworthy job last year in formalizing the organization, defining the duties and objectives of the various directors and committees, and filling the many committee posts with very capable individuals.

Secondly, we have a broad membership base together with senior chapters strategically placed throughout the country. This provides a springboard for an even greater growth rate. Many of our members have made major contributions which have resulted in this most favorable situation, but I believe we can all agree that Matt Payne should be recognized as the man to whom we owe the most in this regard.

Thirdly, thanks to Frank Groseclose and his associates, we have a very good Journal. Our communications and exchange of information and ideas are further aided by Joe Shuri's News Letter.

Fourthly, we have strong regional and chapter organizations which are rapidly gaining experience in the establishment of industrial engineering institutes and conferences.

These resources are being applied in a period of time containing elements most conducive to success—the growing need for, and acceptance of, our services. This very favorable situation was given impetus by the highly competitive forces so keenly felt immediately after World War II.

This brings us to the point at which we should define our immediate plans and consider the best approach for the attainment of our objectives.

The job ahead, as I see it, is to: (1) maintain and improve the strength of our organization through strict adherence to our membership requirements by the chapters and firm and uniform control in the administration of these restrictions by the national; and (2) increase the number of members and chapters. These two factors are the basic ingredients required to place us in a position to provide service of professional caliber.

It may appear that I have overlooked many important areas of activity. This, however, is not the case. Once an organization has attained its optimum size, and growth problems no longer consume such large amounts of time and effort, the functions of the committees assume a more dominant position since they provide the means whereby the organization continues to implement its programs and to provide service and guidance. During the period of initial and rapid expansion, we find that our chief concern is healthy growth and that the key to the problem is the activities of the committees which provide the necessary basis to support this growth. Here we come to the point which I really want to stress today: our growth is directly related to, and dependent upon, the interest created by activities and programs of the committees, regions, and chapters. It has been demonstrated that activity accompanied by publicity will be followed by an influx of new members. Immediately following conventions and institutes, the number of new applicants increases to a marked degree.

Our activities, as established by my predecessors, are quite broad in scope encompassing our relationship with other professional groups, public relations, the News Letter, the Journal, programs, student chapters, publication coordination, membership, organization, and chapter expansion. In addition to this we have a Director of Research responsible for committees on engineering economy, small business, production control, work measurement, material handling, terminology, bibliography, statistical quality control, industrial safety, and new and unusual applications of industrial engineering techniques. There is a Director of Functional Committees responsible for committees on membership qualifications, the constitution, education, professional registration, the national convention, curricula, resolutions, and history. I think that you will agree that this is an imposing array of committees.

We must place special emphasis on:

(1) Regional Conventions. We must continue to encourage and, in every way possible, assist regional efforts to establish annual conventions. Already progress has been made in this direction and the individuals responsible are to be commended for the pioneering work they have done. We must provide guidance, publicity, and, perhaps, even financial assistance if this is necessary and possible.

(2) Institutes. Almost without exception, institutes and conferences have been a success, both from the standpoint of attracting new members and improving the sponsoring chapter's financial position. The sponsoring chapters must be given increased assistance or encouragement. We must bolster this area of activity by means of more wide-spread publication of the results being achieved by the chapters having the initiative and means to sponsor institutes. In addition we must, as in the case of conventions, provide guidance, and, perhaps, even financial assistance if this is necessary and possible.

(3) The Journal. We owe it to the hardworking Journal staff to provide it with greater financial support. The Journal, as it stands today, is the very best which can be achieved, taking into consideration the time, facilities, material, and money at hand. Strengthening the Journal is obviously a matter of vital importance since much of the benefit of our various activities will be lost to us if we do not continue to expand upon, and improve, the Journal—and, for that matter, any and all other publications. Already work has been initiated which should culminate in increased financial support. You may be sure that this effort will receive special attention in the coming year.

To summarize, the future of industrial engineering is dependent upon effective service and an adequate organization. An organization, in turn, can be effective only if it is strong, both in the number and in the quality of its members. Increasing the membership strength, in turn, is dependent upon well planned activities combined with adequate publicity. Continued effort on the part of all committees was never more necessary. Let us press for, encourage, and obtain increased activity, particularly conventions, institutes, and publicity in our regions, chapters, and committees; and we will find that expansion, recognition, and other problems having their origin in the youth and relatively small size of our organization will take care of themselves.

# The Concept Of Flexible Integration

**By Raymond Villers**

*Associate Professor of Industrial Engineering, Stevens Institute of Technology; Consultant in Industrial Management, Routenstrauch and Villers, New York City*

One of the speakers at the recent regional conference of the American Institute of Industrial Engineers, in Washington, D. C., was asked the question: "What is the difference between Operations Research and Industrial Engineering?" His answer was in the form of another question: "Could you first define Operations Research?" The audience understood what he meant—and laughed.

Actually, it seems more and more obvious that both schools of thought tend to rejoin each other.[1] It is not "pure chance" that the past president of the American Institute of Industrial Engineers, our friend, Donald G. Malcolm, is also a distinguished member of Johns Hopkins University's Operations Research Office. Out of the distinct but convergent, rather than divergent, efforts of industrial engineers and of operations research teams, a constructive synthesis of useful concepts may well emerge which cannot fail to improve the general understanding of an increasingly complex field. The sort of rivalry that developed at first between them has probably been a powerful stimulant and may well, in final analysis, prove to be beneficial to both. More specifically, the competition of Operations Research teams has probably been a factor in the increasing attention the industrial engineers have, in recent years, given to the broader concept of industrial engineering. The articles published in this magazine, the books written in the field, the subjects selected for discussion by the program committees of the most recent gatherings of the American Institute of Industrial Engineers (conventions, regional conferences, chapter meetings) all of these factors clearly indicate that the industrial engineer concerns himself not only with specific problems of industrial production, but also—and more and more so—with the whole problem of *organization*.

This is the problem that Charles Babbage characterized in 1832 as "*the general principles which direct the manufactories of the country*" as distinguished from "*the curious processes which we carried in our workshops.*" The very recent developments in the use of electronic computers in industry will, if anything, increase this trend toward giving more emphasis to the problems of organization. Electronic computers provide a new tool of analysis which, in the years to come, is likely to stimulate greatly the use of quantitative methods in solving organizational problems. This obviously means an increased demand for engineering talent in the field of organization. This also brings us back to Babbage. His book, written 125 years ago, is so much up-to-date that the reader cannot fail to be amazed by Babbage's approach and recommendations with reference to general principles of organization, production, human relations, financing or sales management. His cost and time analysis sheet could be used, just as is, by any industrial engineer conducting a process survey in 1955.[2] This is amazing enough. But there is even more. The statement has recently been made, to the writer, by Professor H. Aiken, Director of the Computation Laboratory at Harvard University, that "*Babbage provided 125 years ago all the specifications needed to build an effective automatic computer.*"

Thus, Babbage, this amazing genius, who started his career as a mathematician but soon understood and mastered the problems of the mechanical engineer and those of the industrialist, also foresaw the developments we are today witnessing in electronic engineering. Did he not clearly show us, more than a century ago, that organizational problems have an all-encompassing and synthetic character and that their study should be considered as one single field, regardless of differences in approach or terminology? The writer respectfully submits that the American Institute of Industrial Engineers should proclaim that Babbage was the first Industrial Engineer on record.

It is Babbage again who was the first to call attention to the fact that modern industry, because it requires intense specialization, needs an adequate organizational pattern, something new in the field of organization, corresponding to something new in the field of human activities. Babbage's recommendations for an organizational pattern that would result in what he calls a "judicious distribution of duties" remained of course unheeded. Industry was satisfied to follow the pattern of organization that was available. It adopted the military pattern.

Half a century elapsed before a group of engineers and industrialists, meeting at the American Society of Mechanical Engineers in 1886, expressed once more the idea that modern industry was a type of organization radically different from any other organization and required its own structure. Among them was Frederick W. Taylor who later, around 1900, suggested functional management as a remedy. About the same time, Harrington Emerson proposed the line and staff concept.

Both concepts are still recognized in principle but they are hardly, if ever, applied in their true form, rightly considered as too rigid. They have survived at the price of being applied only in the form of an exception to a rule. Occasional exceptions do not necessarily invalidate a sound theory, but a theory loses its value if the exception becomes a rule. The fact that neither of the above two concepts provides an adequate organization theory is generally recognized today in industry as well as in academic circles. As stated by Professor Dale: "the reconciliation of staff-and-line operations is one of the most difficult problems of organization—the widespread problem (of the clarification of line and staff relationships) has been largely solved on paper, but not in the plant." [3]

An example will illustrate:

The ABC Co. manufactures and sells 1,000 different items constituting a line of consumer goods. A new one, Item No. 1234, is designed, manufactured and sold.

According to "functional management" theory, this item is designed by the design department, manufactured by the production departments and sold by the

[1] See among others—D. G. Malcolm, Operations Research, "Widening Horizon—Industrial Engineering," **Journal of Industrial Engineering**, Vol. 5, No. 5, September 1954; and Robert N. Lehrer, "O.R. or I.E.," **Journal of Industrial Engineering**, Vol. 5, No. 5, September 1954.

[2] Charles Babbage, "**On the Economy of Machinery and Manufactures.**" London, 1832. Unfortunately, very few copies of this book remain available today. Extensive quotations and reproductions will be found in Villers: "**The Dynamics of Industrial Management.**" New York, 1954, pp. 48 to 60.

[3] E. Dale: "**Planning and Developing the Organization Structure.**" American Management Association Research Report No. 20 (1952).

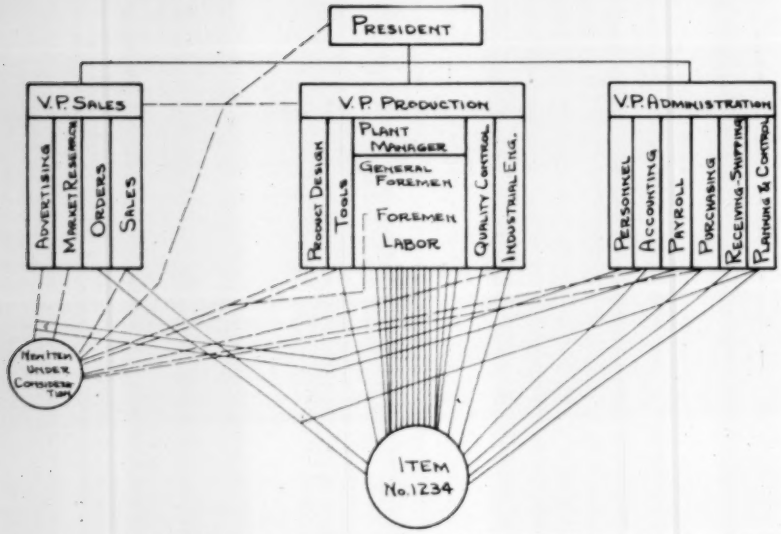


**Figure 1. A study of flexible intergration. The ABC Co. develops, produces and sells Item No. 1234—(one among a few thousands)**

sales department. It is clear-cut and simple, but it implies that each function is more or less self-sufficient, which is not true.

According to "line and staff" theory, Item No. 1234 is manufactured by the "line," which is assisted by a "staff" of designers, cost accountants, plant engineers, inspectors, etc. How simple and clear-cut again. But again, this view is an oversimplification and can be reconciled with the realities of industrial life only by accepting so many exceptions to the "line and staff" principle, that one wonders what has happened to the fundamental principle.

A better understanding of the situation is gained by considering the facts as they are. A brief sketch of actual happenings may be as follows:

At a sales meeting, a salesman mentions the need for a new item in the line. He describes briefly what he wants. The design engineer is present at the meeting. Both are told to work on it. They consult with other members of the organization, the cost accountant and the method engineer, among others. Subsequently, the design engineer, remembering certain production difficulties encountered in department 22, consults with the department foreman so as to avoid creating a similar problem with the new item he is working on. Who designs the item? The design engineer, yes indeed. But also the cost accountant, the method engineer, and also the foreman of department 22. In this capacity the foreman (who is the "line" of the line-and-staff theory) clearly acts as the "staff" of the design engineer! This is not unusual. A foreman often acts as the "staff" when problems of quality, cost or methods arise in a plant.

Later on, Item No. 1234 is produced. Who makes it?

Well, somewhere in the plant, Harold Smith, the press operator, presses the button of a punch press. Does he make item 1234? Yes and no. He alone does not make it, but without him or someone to do his job, the item could not be made. For economical reasons, it could not either be made if Tom Houston, the cost accountant, was not available. Besides, the punch press would not punch if the plant engineer and his crew would not keep it in good shape. Harold Smith would not have a job if the salesman would not sell. The salesman could not sell if the quality control department would fail to stop unsatisfactory products . . .

Is it not true that Item 1234 is made by the integration of efforts of *all* members of the organization? Is it not true that the pattern of relationships needed to effect this integration must be adapted to so many different situations that it cannot and should not be described in rigid terms?

This is precisely the pitfall the concept of flexible integration proposes to avoid.

First of all, this concept is intended to eliminate the distinction between the "line" who "makes" the product and the "staff" who "advises" the line. This distinction between line and staff is in many ways reminiscent of the old-time accounting distinction between the so-called "productive labor" and "unproductive labor," a classification which has fortunately been abandoned. The concept of flexible integration underlines the fact that every member of the organization actually *makes* the product. The salesman and the engineer, the janitor and the president, the accountant and the quality control statistician, yes, they all make Item 1234 at the ABC Co., as well, as much and no more than Harold Smith, the punch press operator. None of them left alone could make it. They all make it by integrating their specialized skills.

Figure 1 illustrates. This graph is not a functional chart and is not a representation of all the relationships involved at the ABC Co. in designing, making and selling Item 1234. If anything, it is an attempt to show that a true picture of the organizational structure of modern industry cannot be drawn, because of its complexity.

Those reluctant to accept the idea that the organizational structure of modern industry is extremely complex may find some comfort in looking at the screen of their television set. There can hardly be any situation more complex than the one prevailing in the room. Billions and billions of electrons originating from Los Angeles, Chicago, New York, Boston, are crossing each other at the speed of light. Yet the picture on the screen is clear and meaningful. It is because this infinite complexity of the interplay of electrons has been fully recognized, accepted and ultimately mastered by scientific handling.

It is the refusal to recognize a complex situation, not its complexity itself, that creates confusion. After it is fully understood, a complex situation can be handled, as shown by our mastery of television electrons.

The concept of flexible integration accepts the growing complexity of the modern industrial enterprise and proposes to master it by:

1. Providing for integration;
2. Providing for flexibility;
3. Organizing for flexible integration.

These three fundamental principles wil be briefly commented upon.

*Providing for integration* is what distinguishes this concept from functional management. It is a recognition of the fact that skills have become so highly specialized in modern industry that no function has any meaning by itself but takes its meaning only in relation to all other functions. The provision for integration results from giving all the necessary attention to obtain a clear definition of the relationships between functions and from creating the conditions of operations in which they can effectively coordinate their activities.

*Providing for flexibility* is what distinguishes this concept from the line and staff theory. It is a recognition that the conditions of integration are so complex and so much subject to change that they cannot be fulfilled if one is the prisoner of a rigid pattern. The pattern must be adapted to changing needs, as they are recognized.

*Organizing for flexible integration* is the logical consequence of the recognition of the need for flexibility. It has for a long time seemed above discussion that the responsibility for organizing, which means defining relationships, planning and controlling, was an implicit

function of management. Once the complexity of the problem is fully recognized, it becomes evident that, while management should continue to make high policy decisions in this as in other activities, the technique of organization should be recognized as a distinct function, requiring a special skill and the time to fulfill special duties.

This amounts to functionalizing the technique of organization in industry. This new function is in charge of adapting the organizational structure to changing needs by defining and, as the need arises, redefining the pattern of relationships within the enterprise. It is also in charge of the procedures of planning and control and can therefore organize for flexible integration.

An increasing number of industrial enterprises, large and small, have recognized this new function. They have created a special department, specifically in charge of it, and designated by such names as: control department, or administrative controls, or planning department, etc. But whatever the terminology used, this amounts to *centralizing the planning and control function.* This new pattern of organization, hardly accepted a decade ago, has gained considerable recognition all over the country during the last few years, as shown by several comments made in articles and books recently written and by communications received by the writer following the publication of an article on the subject.[4]

Simultaneously, as the average industrial enterprise has grown in size, the pressing need for more decentralization has received increasing recognition. Geographical decentralization and decentralization by product have been extensively promoted and in many cases have been applied very successfully indeed. But they both have inherent limitations. The decentralized unit (geographically or by product) is itself, by every possible standard of measurement, a large organization, sometimes a very large one, grouping thousands of individuals. Further decentralization is in order and may be obtained by *functional decentralization*, that is the decentralization of authority and responsibility, along functional lines. This type of decentralization applies to the middle-sized company as well as to the decentralized unit of a large corporation, and is satisfactory both from the point of view of the individual who enjoys a greater freedom of action and from the point of view of the organization, which operates more effectively and more economically. But, functional decentralization requires careful planning and control, and is therefore associated with the centralization of planning and control. Thus, it appears that the general trend toward increasing decentralization is, if anything, likely to stimulate further applications of the concept of flexible integration.

[4] See Villers: "Freedom and Control in the Decentralized Company," Harvard Business Review, March-April 1954

# WHAT MAKES FOREMEN COST-CONSCIOUS?

**Phil Carroll,*** *Professional Engineer*

We hear a great deal these days about making foremen a part of management. Much too is said about supervisory development. And many companies are doing something about these important parts of our industrial successes.

As near as I can tell, the usual method is to use lectures. Giving out information is necessary. Yet, there is a big difference between knowing and doing. To know all the right answers is not enough. We must have actions that are right if we are to get results.

### Incentive Problems

Correct actions in the field of incentives is a case in point. Problems come up daily. Some are stirred up. The reason is easy to see—incentives relate to money—paychecks. The question is, "How best to handle these incentive complaints?"

Your first answer, I think, is "The foreman should." We agree. My reason is that he is responsible for maintaining the working conditions that determine whether or not a time standard does apply. But does the foreman know this? Too often the answer is "No."

### Foreman Training

To tell him is not enough, in my experience. I go further to insist that a foreman should have been an "expert timestudy man." Then he knows when the conditions fit the standard time. Thus equipped, he tends to look for causes when complaints come up. The smarter ones will know before hand and try to correct the causes. Those they must live with will be allowed for in advance. Either way, the causes of complaints are greatly reduced.

### Cost Consciousness

Such an approach has a by-product affect that we should not overlook. It gives the foreman an attitude that is constructive. It makes him more cost conscious. This comes from what I call "chasing .02s around the shop." The hub is the "stop watch" that brings out the small losses we overlook or never know when we are accustomed only to minutes and hours.

All theory, you may say. "What does the foreman think?" you ask. To this, I have two answers. One is the reactions of men I have known who have gone from timestudy work into managerial positions.

* Author of "Timestudy for Cost Control," "How to Chart Timestudy Data," "Timestudy Fundamentals for Foremen" and "Foreman Can Control Costs."

### Foremen Agree

The other answer is better given by the foremen themselves. Let them tell you.

Foreman R says, "Timestudy training has enabled me as a supervisor to fully realize the responsibilities I have to both management and our employees in making our incentive plan strong, sound and controllable so that nobody loses but everybody wins.

Foreman G says, "The overall picture to me is that we improve methods of manufacturing for quality work and reduce cost by putting the cost where it belongs and control the cost by being able to recognize the cost of poor manufacturing.

Foreman P says, "I have learned that "cost control" is of utmost importance if our jobs are to be secure. We must be constantly on the alert for method changes. The company must show a profit in order to stay in business and the foreman is the man who has the hold on the "money bags" so to speak. He can be either *too* generous or be fair to both company and employee."

Foreman H says, "Training in timestudy is of immense value to the shop supervisor in that it causes him to become much more conscious of costs and of their control. It causes him to become more analytical of any proposed changes in order to see whether or not they are economically feasible."

Foreman D says, "The training program made me more cost conscious in regards to small changes that heretofore were disregarded or often not even thought of in daily application of timestudy."

Foreman M says, "I will be more conscious of my duties, both to the operator and to the company. I will be more conscious of wasted effort and I will be in a better position to control cost. I can feel now that I am part of the bloodstream of the company instead of a parasite that is "going along for the ride."

### Foremen Should Supervise

These comments are only the key ideas taken from their opinions. They are biased perhaps by gratitude for additional education. Probably, they include some "apple polishing." Nevertheless, they seem to show that these foremen have a deeper consciousness of their responsibilities as first line managers. To me, that is a greatly desired point of view. It should go a long way toward putting the foreman in the position to correctly supervise his people.

# THE FORECASTING PROBLEM— An Industrial Engineer's Viewpoint

By R. E. McGarrah[1]

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This discussion stresses the importance of the forecasting function as a bilateral decision requiring the viewpoint of manufacturing as well as the sales organizations. Moreover, production forecasting decisions should be more firmly based upon continuing analyses and studies of manufacturing operations and marketing activities, considered as an overall system. Such studies may be termed operations research, and it is at this point where operations research can assure the greatest economies for manufacturing firms.

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The foundation stone of any production control program is the production forecast. It specifies the requirements of the manufacturing program for the future period. This period may be defined as beginning when working capital must be committed (purchase orders, shop orders, etc. must be issued), and ending at the time the products are shipped to customers. The production forecast is not exactly synonymous with the market forecast, although obviously both are concerned with the measure of future demand by customers. The market forecast deals essentially with the prognosis of the market for the products. It is the same as the sales forecast. But the production forecast is *derived* from the market forecast after first, considering the status of finished goods inventories, and second, ascertaining that at reasonable costs, the factory is capable of meeting the requirements of the forecast. If we think of inventories as being positive (i.e. actual warehouse stocks) or negative (i.e. a backlog of firm customers' orders), then the two steps must always be taken. Thus the market forecast is essentially a one-sided analysis of customers' demand, while the production forecast is concerned with both the measure of customers' demands *and* the factory's capacity to meet the demand. The sales forecast is a statement of the future objectives based mainly upon the viewpoint of the sales organization. The production forecast is a revised sales forecast after due consideration has been given to production capacities.

There is an analogy between the sales and production forecasting functions, and the product and process engineering design functions. The product design is based upon primary consideration of customers' performance specifications of the product. Process design begins with the analysis of the product design for the purpose of assuring the economical manufacture of the product. Production designers may "challenge" the product design, and this often results in its revision. Few firms can afford to go into production immediately after a product design has been finalized on the drawing board. The costs of ironing out the kinks in the process of manufacturing successful production models would be too great.

Similarly the sales forecast should be subject to scrutiny by the production organization. The sales forecast cannot by itself represent a true statement of the kind of service customers may expect to receive, unless it is backed up by the production organization.

### Organization Problems

When we realize that time limits the extent of the sales and production forecast analyses for a particular period, we recognize that management faces a critical problem of coordinating the sales and production forecasting groups. On the one hand the salesman may be inclined to complain that he cannot boost sales in the future because the production man will not ship products to the customers on time. On the other hand, the production man may be just as dissatisfied because he feels that the salesman does not give him sufficient advance information about the market requirements for the future. Obviously in the long run, both cannot be right, but in different short run situations, both may be justified in their complaints.

The problem is not completely solved by deciding arbitrarily to increase the stock of finished goods to "cushion" the effects of sudden, unexpected surges in the market, to make life a bit easier for the production organization. Nor would additional stocks provide a buffer for the sales organization, against every occasion when the factory is unable to ship the products to customers on time. In some instances this only aggravates the problem. The dampening effects of such buffer stocks may disguise early signs of upward or downward shifts in sales, so that appropriate action to shift production volume is delayed. It may be too late to take the proper action, and the ensuing results might be disastrous.[2] The addition of finished goods stocks to create a margin of safety which will assure an uninterrupted service to customers, may prove to be worth the added investment of working capital. But the *amount* of additional inventory should depend upon the *measure* of uncertainty of market demand *and* of the factory capacity to manufacture and ship the products to the market on time. Hence we are forced inevitably to face the problem of sales and production forecasting.

Nor is the problem entirely solved by adopting a policy which tends always to subordinate either the production or the sales organization. If for example management were to resolve the issues by declaring in essence that the production organization must agree to manufacture and ship each month any and all products requested by the sales department, it would soon become apparent that the factory overhead costs were zooming out of control. Such a policy applies too literally the axiom: "The customer is always right!" On the other hand, if management's policy were to force the sales organization to limit monthly requirements to restrictions in productive output set by the manufacturing department, competitors would soon be getting the upper hand in the market.

It is essential that both the salesman and the production man recognize the old principle of trying to see the other fellow's problem. The production man must realize that the very life blood of the business, the sales dollar, is being pumped in by the salesman. At the same time, the salesman should remember that the factory may have to incur excessive costs if the products are always shipped on dates promised by the salesman, and this means profits are sacrificed.

To make this principle a reality requires the best kind of communication circuit between the production and marketing organizations. Through these circuits should pass any kind of information pertaining to probable changes in demands to be placed upon the factory. And, equally vital is the information pertinent to changes in the plant capacity necessary to meet probable future market demands. There is no more important circuit of communication in a manufacturing business. We are not concerned

[1] The author is indebted to Dr. M. E. Salveson, Manager, Business Research, General Electric Co., Louisville, Kentucky, who contributed many suggestions, both directly and indirectly in the preparation of this article.

[2] The inventory control problem is magnified by an arbitrary decision to increase stocks. For discussions of this problem, see for example, Todd, F. B. and Scharf, I., "Profitable Inventory Levels," Harvard Business Review, September-October, 1953, or Dickie, H. F., "Six Steps to Better Inventory Management," Factory, August, 1953.

with the usual kind of communication procedure connecting the plant and sales departments, which is sometimes called "customers' service," or "order service." Such communication is of course essential, but the information transmitted is usually concerned with the routine of answering customers' particular inquiries, *after* an order has been received. The channel we are concerned with has to do with transmitting the facts required to keep both the production and sales organizations apprised of what will probably happen in the *future*. This is the information needed for top level planning of sales and manufacturing operations. For examples, the information may come from time-series analyses of customer orders, finished goods inventory levels, and factory production rates.

**Forecasting is a Production Job Too**

The sales forecasting decision includes not only the element of prediction of the future market demand but also the element of *strategy* of the sales activities in the future, to make this prediction become a reality. Obviously the production forecasting decision must be consistent with the sales forecasting decision. The success of the production policy for meeting the future sales demands, depends fundamentally upon the degree to which production and sales strategies are consistent.

Point number one of this discussion is that both sales and production must work together on the job of forecasting. This point should not seem so trivial when one realizes that in too many firms the production organization does not truly and actively participate in the production forecasting decision-making function. In other words the production department is not given (or does not take advantage of) the real opportunity to join the sales group at the time the future sales and production strategies are formulated. This assertion is drawn from observations and experience with production control problems, and it seems to be a logical and an obvious conclusion. If the production man *had* participated in determining the production strategy, one cannot imagine that production control problems would have to be continually dealt with as if they were a series of emergencies. Yet the job of production control often entails "putting out one fire after another." We find that shortage lists seem to remain their usual *many* pages in length, even when stocks of fabricated parts for the assembly department are bursting the sides of the stockroom. And, in spite of the volume of production, the number of shop expediters who chase after all the parts needed by the assembly department, never seems to be sufficient. Frantic telephone calls to vendors, to shop foremen, etc., seem to be the rule rather than the exception. If the production manager did actively participate in making the program decision, surely the production control routine would seem less hectic. When the salesman unilaterally decides the monthly production forecast, he cannot be expected to appreciate the high costs of such production control procedures. A good production man, working closely with the sales forecaster, would take advantage of the opportunity to improve his production schedule and thereby avoid some of the emergency tactics of dealing with production problems.

In some of the recent discussions of production control, we read of the analogy of production control principles to servomechanisms.[3] The servomechanism is a system in which a change of one of the input components of the system is automatically transmitted to cause a controlled response by one or more of the output components of the system. For example, the thermostat in the room transmits the change in the room temperature to the control switch on the heater in the basement, and the heater responds by warming the room. Or, perhaps if the room temperature had been too high, the blower responds by circulating the air in the room for cooling purposes. Thus the analogy of the servomechanism would imply a kind of automated production control system, in which a change in the market demand for the products is automatically transmitted in such a way as to cause an immediate and controlled response by the factory in meeting the new demand. From the viewpoint of minimizing operating costs, the best kind of response would be to have inventories absorb the small, high frequency variations in the sales level, and to have changing production rates absorb the large "amplitude," low frequency variations in sales.[4] This of course is the ideal we are all seeking. The servomechanism analogy applies to production control at virtually all functional levels of production control, but on no occasion is it more important than at the time of determining the production and sales forecast.

As in a servomechanism, the communication between the sales and production groups is a two-way proposition. The sales organization reports information on the market demand to the production organization. Production immediately takes the necessary steps to change the factory facilities to enable the plant to render the service required. In the other direction, the production department informs sales that a change in the factory facilities has involved large sums of the firm's money. Therefore it is encumbent upon the sales department to organize its selling campaign so that a fair return on this investment can be assured. The production organization has reason to expect the sales department to take the necessary steps to create the sales dollars.

Thus the successful forecasting function requires competent sales *and* production analysts who work together, feeding pertinent information back and forth to each other. Each analyst would gather and analyze information from his respective area of operations. The sales analyst would obtain data on probable market demands, summarize the data, and then would turn to the production analyst, asking (in effect) ". . . can you meet this new demand?" The production analyst in the meantime would have analized the latest data on restrictions in current plant capacity, and could give a fully qualified answer, which might say for example, ". . . yes, but it will cost us X dollars of overtime, or, . . . we will have to lay off temporarily X number of employees which will cost us Y dollars to change the level of production volume." Alternatively the production analyst, having examined data on current restrictions in plant capacity, might say to the sales analyst, ". . . factory capacity is such that if we were to produce and sell X dollars of product A, our profits would be increased Y dollars from what they are now with the present "mix" of products being sold, can the sales department do this? In such a manner the strategy selection procedure is not just a matter of sales forecasting, but also production forecasting—indeed it is *programming the business operations as a whole.*

**Analyses of Factory Operations Needed.**

We know that the market demand for a product is subject to many kinds of variations from one period to the next. To study these variations, firms have employed the best available talent and facilities, including economists, statisticians, electronic digital computers, Teletype apparatus, etc. But do we also realize that in most if not all manufacturing operations, the capacity to produce is also subject to many causes of *significant* variations? Determining the factory capacity is not simply a matter of summing the number of machine tools available, or employees on the payroll as of a particular time. The factory is a complex system made up of men, materials, machines and methods which are always undergoing some kind of change. Hence the future aggregate capacity of this system for a particular period is seldom known with any degree of precision. Seldom does a factory manager know how all the components of his facilities interact to define his capacity limitations. The goal of the production manager is to meet the customers' requested delivery dates, in some overall optimal manner; however during some particular week or month, the plant will very likely experience unforeseen difficulties which cause it to fail some particular customers' requirements for delivery.

[3] Simon, H. A., "Servomechanism Theory in Production Control," Econometrica, Journal of the Econometric Society, Chicago, Illinois, April, 1952, p. 247.

[4] Simon, H. A., and Holt, C. C., "Optimal Decision Rules For Production and Inventory Control," Proceedings on a Conference on Operations Research in Production and Inventory Control, Case Institute of Technology, Cleveland, Ohio, January 20-22, 1954.

The second major point of this discussion is that the production forecast requires better, more thorough analyses of manufacturing operations, treated as a whole. It may be argued that the factory manager ought to know precisely the measure of his plant capacity, because he has a staff of timestudy engineers, production engineers, production scheduling clerks, budget planners, etc. —all engaged in deriving or using some kind of measure of factory productivity. The fact is, however, that few factory organizations have staffs deployed *continuously* in the work of synthesizing the data on manufacturing operations, considered as a whole system. For example, take the manufacturing time cycle, which is comprised of essentially three basic time phases:

1. Design—The time required for product design and development, process design, including tool design, method specifications, etc. (If products are of standard designs, this phase may be ignored.)
2. Procurement of materials—The time required for the purchase requisitioning, ordering, receiving, inspection, and stocking of vendor-supplied items.
3. Manufacturing Operations—The time for fabricating and assembling parts into finished products, ready for shipment. The time required to ship the products to the market may be considered as part of this phase, or as an additional phase.

The duration of these time phases is subject to variation, and depends upon a multitude of causes, such as varying reliability of vendor services, the policy regarding the control of material stocks, both raw and in-process, the progress status of the load already assigned to the factory for a given period, the reliability and validity of the time standards used to estimate the amount of manufacturing time involved, the policies and procedures for dispatching the work to the shop, etc. The extent of such variations is significant because on the one hand if the actual time required by the factory to ship products is greater than the time quoted to a customer, it may mean the loss of a sale or customer goodwill. On the other hand if the actual time required is less than the time quoted, it may mean excessive overhead costs due to excessive inventory, or that opportunities for additional sales have been forfeited because the salesman was unable to offer the desired promptness of delivery to other customers. Yet in spite of its obvious significance it is believed that few firms measure quantitatively the statistical nature and causes of the variations in the manufacturing time cycle required by the factory under different conditions.[5] There can be no doubt that management should have this information if the sales and production programs are to be mutually consistent. If it is worth the expense and effort to work continually in the study and planning of marketing operations, it is also worthwhile to engage in continuing study and planning manufacturing operations, which of course must respond to the results of decisions affecting the marketing program.

An initial study to determine the need for a continuing analysis of the problems of programming manufacturing operations might involve a comparison of your company with other competing firms in the industry. For example, if over the years, the ratio of the cumulative average operating profits (before income taxes) to the sum of the manufacturing cost of goods sold plus inventories plus fixed capital is high, relative to other firms, chances are your company is doing a good job of programming its operations. If it is low, then there is need to engage in continuing studies to improve the programming of the business operations.

The benefits from the results of a continuing study of production operations are well worth the investment in the technical personnel, computing equipment, and other usual required costs of such staff work. Among the possible advantages are improved production programming and better planning and budgeting for plant capital expenditures. Improved production programming will make the *existing* factory facilities more productive because fewer delays are encountered; production scheduling and control problems become less critical. If the production forecaster knows the restrictions in the manufacturing capacity in quantitative terms, he can make significant contributions to programming future business operations (i.e. marketing and production operations).[6] It also means that management has a useful basis for classifying the various factory facilities (i.e. the work centers or departments within the plant) according to the severity of their respective restrictions to the overall factory capacity. This provides a useful indication of additional equipment needed (machine tools, materials handling equipment, etc.). Hence the factory management has a more explicitly understood basis of deciding the problem of where to increase plant capacity with the limited funds available; in the process, management is also given the key to a well-directed cost reduction program involving better tooling, rearrangement of equipment, improved methods, etc.

**Summary and Conclusions.**

Deciding the strategy of the business operations is not a function to be delegated solely to a salesman, or other marketing staff. The sales forecast is vital to the success of the business operation provided it is properly weighed in the deliberation leading to the basic production program. Thus the production organization should participate in the strategy decisions of the forecast, and there should be continuing exchange of information concerning future operations in the activities of both marketing and manufacturing, before manufacturing operations are committed to a production program.

The validity of the production forecast depends upon the precise knowledge of the current and future manufacturing capacity to meet the demands of the forecast. A competent staff engaged in a continuing study of the manufacturing operations, considered as a system, can furnish management with more reliable bases for production programming decisions. Such a staff would require engineers who are versed both in the application of the necessary mathematical, statistical and economic theories *and* in the realities of management practice. They should be familiar with mathematical programming, matrix algebra, statistical measures of probability, small sample theory, concepts of incremental and opportunity costs—to name a few pertinent theoretical principles. And to assure that these engineers make their most effective contribution to more profitable managerial decision-making and programming, they should be familiar with the practical problems of management, such as production and inventory control, plant layout, materials handling, cost and quality control problems. In addition, these engineers should be given organizational status which will permit them to pursue their studies, to seek necessary data and functional relationships, and to report their findings impartially, without bias arising from organizational preferences. Usually this will mean they should be on the staff of the top manufacturing executive.

Thus the novel aspect of the concepts discussed here is not the scientific or engineering method itself, but the *application* of this method to the business as a whole, and in particular to programming the business firm's activities in accordance with the *simultaneous* requirements of both production and marketing. Some writers assert this recent extension of industrial engineering creates a new discipline which they term "operations research."[7] Other writers assert this extension of application of engineering techniques from manufacturing to the business firm as a whole is simply a logical, evolutionary development and refinement of the already defined field of industrial engineering.[8] In any case, it is clear that whatever it is called, this new application of the scientific method to programming the business operations *as a whole* has made important contributions to industrial efficiency by coordinating better the functions of both marketing and production.

[5] The manufacturing progress function, described by F. J. Andress in an article entitled "The Learning Curve as a Production Tool," Harvard Business Review, January-February, 1954, may prove to be useful in such a study, although not without careful discrimination.

[6] In this connection, see for example Arnoff, E. L., "The Application of Linear Programming to Production Engineering and Scheduling," ASME Paper Number 54-A-223, The American Society of Mechanical Engineers, New York, New York, 1954.

[7] Hermann, C. C. and Magee, J. F., "Operations Research for Management," Harvard Business Review, July-August, 1953.

[8] Salveson, M. E., "The New Look in Industrial Engineering," Journal of Industrial Engineering, November, 1954.

# ECONOMIC CONSEQUENCES OF AUTOMATION*

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The economic development of the United States in the last fifty years has been described as revolutionary. This paper will consider only one aspect of this complex and challenging process—recent developments in the field of business controls. A complete examination of all the implications of this subject is not attempted here, but it is believed that some of the more significant effects of the new system of automatic control have been considered.**

Businessmen deplore "controls" which take the form of external restraints placed upon their firms, but they simultaneously endeavor to increase the scope and effectiveness of their own system of internal control. Ralph C. Davis defines business control as "the function of constraining and regulating action in accordance with the requirements of a plan for the accomplishment of an objective. It is achieved through the proper correlation and coordination of the activities of the business organization. It may take place at any managerial level, either operative or administrative." [1] This definition, it should be stressed, is not accepted by all authorities. Nevertheless, it encompasses the area of business operations to which this paper will refer.

Although rationality in business operations is of recent origin, the emergence of control as a separate function of management is an even later development. Discoveries in the fields of electronics and communications in the last decade have finally permitted the manufacture of automatic computing equipment capable of translating a large body of previously developed principles into practical significance. Underlying this process is the growing conviction of the twentieth-century businessman that something can be done to increase the efficiency of his business operation. As Arthur Cole has contended, Frederick Taylor's great contribution was not in his principles of scientific management. It was in the idea which he fostered that an executive need not rely exclusively on experience, but could increase the efficiency of his firm by critical thought applied to the results of careful research.[2]

That romantic figure, the nineteenth-century entrepreneur, has largely vacated the American industrial scene, having been relegated to a portion of the service and retail areas. This man of daring and imagination who relied upon intuition and "vision" or, perhaps more accurately, hunch supported by experience, has become a technological casualty.

The businessman of this century avails himself of an ever-expanding body of knowledge with which to aid himself in his decision-making. Periodic statements and reports emanating from the accounting, sales, legal, and other departments pour onto his desk. Conferences with lesser executives increase the scope of his knowledge. Thus, the development of the more rational economy has had numerous implications for management. For one thing, it has brought into being a new concept of business organization. The top executive can no longer have knowledge of all the details of his firm's operations. He has been forced to rely on his subordinates.

In effect, there has been a steady movement away from the authoritarianism of the Robber Baron—Industrial Statesman, so that the present day executive views his task as more than the mere manipulation of men and materials. Rather he thinks of his functions as consisting of planning, coordinating, controlling the operations of the firm and harmonizing the interests of employees, investors, suppliers, and customers.

The introduction of mass production has materially altered the character of industry. As Oswald Knauth has pointed out, business ceased being an operation that could be stopped and started with small loss. Rather, it became necessary that it be thought of as a flow of goods, sometimes requiring a twenty-four hour operation. Concurrently, the task of management changed. The shrewd bargain lost its significance and regulation of the flow became the dominant concern of the firm.[3]

One of the most significant differences between the businessman of today and his nineteenth century counterpart lies in the improved knowledge of the contemporary executive who has superior means at his disposal which permit him to more accurately predict the future. Evidence to buttress this contention of increasing rationality and enlightened planning is easily found even in the unlikely field of accounting.

Standard cost accounting makes possible closer executive control over plant operations because of the existence of variance reports which reflect efficiencies and inefficiencies in operations. These reports can be prepared daily or weekly according to the wishes of management, precluding the necessity of waiting until the end of the month for operating information. However, not only has management been placed at an advantage by receiving more useful data, more quickly, which appears to have been the most plausible explanation for the original development of standard costs, but comparison of actual figures with standard figures in simpler, quicker, and usually more reliable than historical comparison.

In like fashion, the availability and usage of electronic computers will cause a remarkable change in what management expects of its accounting and reporting system. With the notable exception of standard cost, accounting has been practically valueless as a forward-looking tool. One observer has concluded that "Management has been driving down the business highway using only the rearview mirror." [4]

It must be remembered however, that forecasting business operations, given existing techniques, requires a tremendous amount of statistical manipulation. The considerable expense, coupled with the lengthy time periods involved, serve to discourage the utilization of these rational practices. The speed with which the computer performs its functions in conjunction with its ability to follow through an exhaustive series of complex operations, promises to present an expanding horizon of useful management control information.

The new technology, which has been variously named, but which seems to have been most widely looked upon as automation, is taking form at the same

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* An address delivered to the Southern Economic Association annual meeting in Biloxi, Miss., November 19, 1954.

** The writers are obligated to Professor Arthur Schweitzer of Indiana University who read and criticized the first draft of this paper. The responsibility for any shortcomings in the paper, however, lies solely with the authors.

[1] Ralph C. Davis, **The Fundamentals of Top Management**, Harper & Brothers, 1951, p. 637.

[2] Arthur H. Cole, "Twentieth-Century Entrepreneurship in the United States and Economic Growth," in **American Economic Review, Papers and Proceedings, May 1954**, p. 41.

[3] Oswald Knauth, "Group Interest and Managerial Enterprise," **The Journal of Industrial Economics**, April, 1953, p. 88.

[4] John A. Higgins and Joseph S. Glickauf, "Electronics Down to Earth," **The Harvard Business Review**, March-April, 1954, p. 100.

time as advances are being made in mechanization, thus often causing confusion of the two types of technological innovation. Nevertheless, automation represents a sufficiently radical change from new mechanization to warrant an examination of it in its own right, for automation shows promise of as great an improvement over current methods of business operation as the mechanized factories of the Industrial Revolution proved over the gild craftsman of the Middle Ages.

Since the end of World War II, a variety of electronic machines has been constructed which are capable of performing automatically, a series of logical operations, choosing among several previously anticipated courses of action based on built-in criteria, and adjusting for errors.

Basic to the operation of all automatic processes is the concept of feedback control. The input of machines utilizing the feedback principle is regulated by the machine's own output so that the output meets the conditions of a predetermined objective. As in a simple, thermostatically-controlled, heating system, the conditions created by the output, control, in turn, the amount of input and hence the performance of the machine.

Automation has given evidence that it is capable of radically altering both the production and administrative processes of the business firm. The greatest amount of attention has been concentrated on the use of high speed digital computers performing routine office functions already handled by less efficient, slower machines. This limited conception of the usage of automation is understandable. Most persons lack the imagination to envision anything more extensive than this. An official of the General Electric Company explained that computers are only expected to perform routine, unimaginative functions at first; functions which formerly had been handled by less efficient machines. These functions included handling payroll material, scheduling, inventory control, order service, billing and general cost accounting. G. E. believes that the more spectacular use of the equipment will arise only as its employees and management develop "on-the-spot" experience through direct use of the machine for the more prosaic matters.[5]

However, electronic computers can use current sales forecasting analysis to automatically adjust and integrate the chain of interrelated operations such as management, planning, sales, supply, production, budgeting, and accounting. Models, in the form of electrical networks, can be constructed and studied by the business economist. Artificial disturbances analogous to assumed changes in economic variables can be employed to determine the consequences of alternate courses of action. The enormous speed with which complicated problems may be solved greatly increases the possibility of experimentation within relevant time periods. For some business operations, computers can replace almost the entire workforce. For example, John Diebold, who is the recognized authority on automation, maintains that the record-keeping and filing functions of an insurance company, which now require a fifteen story office building and a large staff, could be replaced by a computer, two operators, and a small room.[6]

There is an increasing awareness of the potentialities of these computers. This is evidenced by the remarkable growth of their manufacturer. In 1954, 750 firms sold about three billion dollars worth of control systems and their components to private industry and the government. Computer manufacturers claim that any firm with five hundred or more employees can profit by owning a computer or even renting one at the going rate of twenty thousand dollars a month.

Examples of advantages to the firm arising through the use of automatic control systems can be found in cost reductions, less waste, higher output and a more uniform product. Among the most obvious immediate advantages which may accrue to labor are safer working conditions, shorter hours, and the creation of a host of skilled jobs such as maintenance, repair and design which replace many tasks assumed by the machinery. Consumers may expect more and newer goods of better controlled quality.

On the other hand, the computer age requires a greater degree of comprehension and farsightedness on the part of management and labor than may be readily forthcoming. For example, rapid change-over times and a greatly decreased work-in-process inventory requires more alertness and greater technical knowledge of managers than ever before.

Despite the publicity given the computers by science-fiction type reports, and the close analogy between the operation of electronic control systems and human nervous systems, it must be emphasized that computers do not, by any stretch of the imagination, have intelligence. In fact, the machines are only capable of performing those functions which are predetermined for them and even then they have no powers of judgment. They can be programmed to make certain routine decisions based on built-in criteria but the function of decision-making in the firm has by no means been reduced by the installation of computers. Indeed it might well be said that finally it will be possible for the manager to more effectively concentrate his energies on purely managerial functions leaving the more routine matters of record-keeping, filing, budgeting, accounting, etc. to the almost infinitely more efficient machine.

Any discussion of existing or prospective scientific control devices must take into consideration the widely diversified forms of business organization in the American economy. Thus generalization in this broad area would be unrewarding. Nevertheless, much discussion has ensued concerning the possible effects of automation. There are some predictions of sudden and widespread technological unemployment and large-scale labor resistance. Oddly enough, these predictions have not come from the spokesman for organized labor or from economists, but from the scientists who have developed the theories upon which the automatic computer operations are based.

During the last fifty years there has been an increasing fascination with the possibility that super-rationalism in business might spill over and transform society into an exact mechanism in which all elements of chance, risk, capriciousness, and free-will would be eliminated. This had led to widespread predictions that the form and essence of Capitalism would be replaced by radically different systems. Ghent and Belloc pictured a new feudal baronage which controlled all economic and political life and provided security and a permanent low status for labor.[8] Burnham predicted a managerial society in which a vast self-perpetuating bureaucracy of executives made the important decisions.[9] Schumpeter thought that Capitalism would crumble under the impact of its own success as the entrepreneurial function became obsolete and progress became automatic.[10]

In spite of the influx of startling innovations which indeed herald a new level of technology, there is nothing which indicates a cataclysmic change in the Capitalistic economic system. Although automation may be expected to introduce radically different processes and attitudes which may be referred to as revolutionary, such changes are likely to affect only a limited sector of the economy.

An evolution of economic and social institutions can be expected to continue, but no social revolution seems to be in the offing, at least in the sense that revolution means technological or institutional changes which occur more rapidly than society can assimilate them.

For the purpose of determining the extent to which automation can be applied to productive processes, industries can be divided into three classifications. The first includes those industries in which production can be reduced into a continuous flow process. Oil refining, flour milling, and chemical production

[5] Roddy F. Osborn, "GE and Univac," **The Harvard Business Review**, July-August, 1954, p. 101.

[6] John Diebold, **Automation**, Van Nostrand, 1952, p. 94.

[8] W. J. Ghent, **Our Benevolent Feudalism**, New York, 1902. Hilaire Belloc, **The Servile State**, New York, 1912.

[9] James Burnham, **The Managerial Revolution**, The John Day Co., 1941.

[10] Joseph Schumpeter, **Capitalism, Socialism, and Democracy**, Harper & Brothers, 1950.

are illustrations of industries in which automation has made, and should continue to make, significant progress. In other industries it is possible to revamp the productive mechanism in such a way as to convert it from a series of unit operations into a single endless process. As John Diebold warns, in considering automation, it is most important that one does not fall into the trap of thinking of automatic production as a process of automatically duplicating the motions of the present machines or workmen. While some industries utilize processes which are not conducive to automation, new methods of production may be conceived which are more acceptable.[11]

A second class includes industries in which some automation is possible, but full or nearly complete automation is not likely. Indeed, it is possible that some industries may have automatic machines applied to seventy-five per cent of their operations, yet the cost of making the plant completely automatic would more than offset the savings achieved from the use of partial application of automatic machines. In this category would be found industries which require substantial information-handling and accounting functions but in which the methods of production or the nature of the product is not adaptable to continuous flow techniques. Such industries include transportation, large-scale retailing, and the manufacture of certain nonstandardized consumer products like furniture.

The third group into which all industries may be classified includes those in which the highly individualistic nature of the product, the need for personal services, the advantages of small-scale units or vast space requiremehts preclude any significant application of automatic controls. These would include agriculture, mining, professional fields, and most construction and retailing.

Any attempt to appraise the impact of a system of business control on the economy must consider probable changes in the pattern of market competition. Consequently, effects on the number of firms in a given market, their relative size, and the established forms of behavior in the industry appear necessary subjects for examination.

The most obvious influence on size results from the very high initial expense of automatic control systems. Although an enormous expansion is occurring in the manufacture of all kinds of electronic control devices, prices are not likely to be materially reduced for some time. The rapid rate of innovation in electronics and the continuous discovery of new applications of automatic control systems tend to postpone mass production. Consequently, these machines tend to be designed for individual order and therefore production must occur under the most expensive conditions.

[11] John Diebold, "Automation—the new technology," **The Harvard Business Review**, November-December, 1953, p. 66.

It is apparent that only firms with considerable resources will be able to take advantage initially of the new control machinery. Price reductions may make automatic controls available later to firms with limited resources. However by this time, their market position may have deteriorated for one of two reasons. Either they may have been squeezed out of the industry by the lower costs of their large automatized rivals, or their position may have become tenuous as they are only tolerated in the industry for an appearance of competition in order to avoid public disfavor or government anti-trust action.

Some firms with adequate resources may be reluctant to automatize their operations, but they may be forced to adopt automatic controls, if a competitor does so, even if it requires scrapping or selling undepreciated machinery. The alternative is to risk losing their established positions in the market.

The effects of automation on the inherent tendencies in large-firm industries toward maintenance of the status quo and the perpetuation of traditionalism remain to be discovered. To the extent that inter-industry competition is conditioned by the action of individual firms, the introduction of automation may disturb the relative positions of entire industries.

Although a sizeable concentration of capital is necessary before a firm can achieve the economies of computer operation, there is reason to believe that automatic control devices may lead to decentralization of plants. The growth of electricity and the introduction of lightweight fabricating materials have already permitted plants to be located at great distance from power and supply sources. Since automatic equipment requires little direct labor, there will no longer be any compelling need to locate automatic production plants near large population centers. Of course, decentralization of production may be accompanied by further concentration of ownership if established firms take the lead in expanding into more remote areas. Decentralization of plants does not necessarily result in less concentration of market power. It may result in greater concentration.

There is another aspect of the impact of automatic controls on the location of industry that appears worthy of examination—the effect of automation on the location pattern of labor-oriented industries. The attractiveness of low labor cost regions will be markedly lessened, often to the point of elimination, in those industries in which automatic controls may be largely or completely utilized. This will occur because of two reasons: first, the number of workers in the automatized plant is considerably smaller than in the non-automatized plant thereby lessening the savings to be achieved by employing cheap labor. Secondly, the automatized industry labor force is primarily composed of skilled workers and there is usually a smaller regional wage differential between skilled workers than exists between semi-skilled or unskilled workers of different regions.[12]

Automation does not promise to create as much secondary investment as have some of the earlier developments in technology. The introduction of the automobile and the resulting increase in primary investment in that industry stimulated a wave of investment in the oil, rubber, highway, and construction sectors of the economy. In this respect, automation will not make the far-reaching investment impression on the economy that the introduction and later improvements in automobiles, railroads, and canals, for example, created.

Perhaps the most widely discussed economic effect of automation has been technological unemployment. Fear has been expressed that the greatly reduced labor requirements of automatic factories will lead to a persistent shortage of job opportunities in the economy. As an economy-wide problem this argument seems to be overdrawn for several reasons. First, automation will be limited to industries which employ, at the most, 25% of the labor force. Second, automatic controls do not replace the labor force entirely, although in terms of labor hours there is a considerable saving. As routine clerical and operative jobs are abolished, new maintenance and technical jobs are created which will go far toward off-setting the loss of former jobs. Third, extensive training and educational programs will be required as the labor force is upgraded and this will to some extent counteract unemployment by delaying entry into the labor market. Fourth, the fact of automation will not occur simultaneously in the different industries. Such technological unemployment as is created will tend to be spread out over a long time period and thereby make less difficult the absorption of the unemployed workers into the labor force.

In spite of these mitigating factors, however, the severity of technological unemployment on the individuals affected should not be underestimated. Those who disparage fears of technological unemployment often assume the existence of a self-adjusting labor market. However, there is a real danger that imperfections in the labor market will seriously delay absorption of the displaced workers.

Automation results in a general upgrading of the labor force as routine and uninteresting jobs are eliminated and more responsible and challenging jobs are created. In the past, as machinery has replaced men in production, energy has been released which was partly absorbed by an expansion of employment in travel, entertainment, and personal services. Automation should accelerate this process. Mechanization has also

[12] In criticizing this paper, Professor Joseph Alroy of Emory University suggested the subject-matter of this and the following paragraph.

**(Continued on Page 26)**

# What Makes A Budget Successful?

By J. L. Peirce, *Vice President and Controller, A. B. Dick Company, Chicago*

*From a talk given to the Metropolitan Chaper, American Institute of Industrial Engineers, Inc., New York, March 21, 1955*

There is certainly very little new to be said about the principles of budgeting. Business and management periodicals are replete with ideas of all sorts on the subject, hundreds of books have been written on it, and hundreds of thousands of words of intra-company conversation have been devoted to the never ending questions it raises.

Nevertheless, strange as it seems, the field of budgeting is still alive, and people go on asking each other about their experiences in it. I think there is a reason for this. I think it is because we are just beginning to see it all in a new light. The door has just opened a crack to reveal the grandeur of a new viewpoint—that budgeting is not figures, standards and mathematics, but, rather, it is people. It is people's thoughts, people's attitudes, even the emotions of people that make or break a budgeting program.

When these ideas and attitudes are skillfully cultivated and channeled, and when we have at the same time a management honestly motivated and sincere in its efforts, the budget can be made to work.

Now that these facts are becoming more clearly recognized, more and more companies are enabled to look backward a few years and see their own mistakes, standing out like fence posts. By so doing they may be able to turn them into guide posts, so that other companies may profit thereby.

### Budgeting is a Science

The fascinating thing about budgeting is that it is a science—and, like any science, it can be practiced according to fixed principles and rules. If these are followed, the budget practice is successful; if they are not, the budget practice is proportionately unsuccessful.

Well then, why do we not—all of us—pay more attention to the task of uncovering, developing, stating and disseminating these rules and principles? If we do not, our businesses will be outdone by the companies which do; and we will be victims of competition, not in products or markets, but in progressive management.

Not only is budgeting a science, but as a science, it has unique characteristics which are seldom acknowledged. As I have already hinted, it is a science of human relationships rather than figures. It is positively grounded in such things as individual incentives, personnel development, sound organization principles and human values. Properly handled, it establishes mutual goals, cooperative efforts to achieve them, and the wholesome atmosphere of free enterprise within the many little business units which we call departments.

### As an Example

To make of ourselves an effective case history, I will give you a brief portrait of our company. We have been manufacturers of office duplicating equipment and supplies for some seventy years. Nearly all of our plant facilities and our general offices are under one roof in suburban Chicago, comprising about 600,000 feet of floor space. We have about 1,700 employees. Our production is divided between duplicating machines, which is mechanical fabrication and assembly, and duplicating supplies, which is chemical and paper processing.

The products are thought of in the trade as a specialty line and do not lend themselves to mass production methods. They are marketed through about 240 independent distributors in the United States and to a small extent in foreign countries. We also do some business in sub-assemblies classifiable as munitions.

We took our first faltering steps in the budgeting field in the late thirties, when we began to prepare budgets for various general office and plant departments, and for the twenty retail branches which we maintained at that time. The idea germinated in the office of the Controller (my predecessor) and from there burst like a Fourth of July bombshell over the rest of the organization.

It took quite a long time to convince the management of that day—seasoned and steeped in the more autocratic methods of an earlier era—that budgets were needed at all. By the nature of things; someone had to act, and the Controller therefore established the expense budgets. He then informed the various department managers as to the amount of each item therein, at the same time getting the approval of the president.

Perhaps you can visualize, or have yourselves experienced, the friction produced by this set-up. No one was quite certain who was responsible for enforcement. The budgets were accepted in various ways by the individual managers—with enthusiasm, with tolerance, or under protest. All were somewhat confused, but the show was on the road, at least, and though the Controller's popularity ebbed to a new low, we had the beginnings of a budget system.

### Lesson No. 1

Out of this confusion came our first big, valuable lesson. It was costly in both money and time, but worth every dollar and every hour of its cost. The lesson seems elementary to us all now, yet every so often we hear of its being ignored. It is simply this: that a man must make his own budget. If a given department manager is to be held accountable to a budget, he himself must be permitted to establish that budget.

To put it another way, you hire a man to do a specific job—and I don't care whether the job is to run a screw machine department or to merchandise umbrellas in Brazil—and the first thing you do is to define carefully the job you want done. With that part understood, you then ask him what he will have to spend in order to accomplish it. He tells you and if you approve his requirements, that becomes his budget.

If you do not approve, then you discuss the matter with him, and perhaps you get him to agree to a different plan. The important thing is that, as a responsible manager and an independent thinking individual, not dominated nor intimidated by you or anyone else, he agrees to the dollar amount. It becomes his own and he accepts it in a responsible way. Knowing the job to be done, he has established his budget. No one can successfully do it for him.

While we are on this point, let us take a moment to dispel the specious counter-argument—that when you allow a man to set his own budget, you have lost control. In the first place—assuming you are his boss—you have defined the job he is to do and you retain the right to direct his activities. You appraise his results and you are the principal factor in his compensation and promotion. Exercised wisely, these prerogatives ought to be more than enough to keep your man from going off the beam in establishing his budget.

### Realistic Planning

Furthermore, we came upon another interesting truth in the early days of our budgeting adventuring. Strange though it seemed at that time, men set their own budgets too low oftener than they set them too high.

This arose from various causes. Partly it was ignorance, by which I mean the tendency to omit provision for any unforeseen contingencies whatever, ignoring the lessons of the past. Partly it was overoptimism. Partly it reflected the confident anticipation of doing a good job and the wholesome willingness to work to a tight standard. Generally speaking, the practice of padding budgets did not appear until we had made a second major mistake, namely adher-

ing rigidly to a budget figure despite changes in conditions for which the man could not be held responsible.

This leads to lesson number two, drawn directly from experience. We had to learn the hard way that there are circumstances in which the budget must be exceeded without adverse effect on the appraisal of performance.

Conditions surrounding a given operation simply will not remain static. They change, and the light in which yesterday's decisions were made is not the light of today. New demands are levied, new contingencies encountered, new challenges faced. Spending more than the amount budgeted may well be in the best interest of the company.

For example, when new or improved products reach the end of their long course, which has taken them from the idea stage through research, development, design, prototype, testing, redesign, tooling, and so on, they are at last ready for introduction to the field. It is at this moment that sales promotion and advertising effort must be applied. If this acceleration of the expense level has not been provided in the budget, something must be done to permit the expenditure, in order not to lose the value of proper timing in putting the item into the market.

Now if good planning underlies the preparation of budgets, this particular type of incident will be relatively rare. Nevertheless similar situations will always persist in business. Good common sense will dictate going over budget limitations.

### How Best to Exceed the Budget

How shall this be accomplished without wrecking the foundations of the budget structure? It is certain that the way *not* to do it is to encourage the responsible manager to go ahead and spend the money, unsure whether or not his action will be approved, and afterward, with a guilt complex, having to beard a frowning controller.

Another of the more popular wrong methods is to refuse to spend the money because it is not provided in the budget, even at the risk of injury to the company. One of the waymarks in our budget progress occurred in this area. A foreman, when asked for a raise by one of his men, admitted that the man was entitled to it, but refused to grant it on the ground that it was not provided in his budget. In the ensuing crisis, we were forced to undergo what a Dulles might have called an "agonizing reappraisal" of our budget attitudes, and particularly of the understanding of those attitudes in our supervisory organization.

Perhaps it is now time to look at the *right* method of exceeding budget. Having learned the lesson, we find that this circumstance occurs regularly and without undue friction. As an illustration, let us assume an unforeseen delay in the design of a new machine, requiring several weeks more time than anticipated to produce the parts drawings. Faced with this situation, the Manufacturing Division realizes at once that its Tool Room cannot turn out the required tools to produce the model in time for the scheduled introduction date.

The alternative to failure to introduce the item to the field on time is to farm out some of the fabrication of tools to an outside shop, at a cost well in excess of producing them internally. This course of action will have several effects on the company's budgets. The increase in cost of the tools known as perishable (those not capitalized) will represent a breach of the Master Mechanic's expense budget for several months. The increase in cost of the tools known as permanent (those capitalized and amortized) will cause an excess over the Master Mechanic's capital expenditure budget. The amortization charge for the higher cost of tools will also be greater than planned, thereby raising charges to current operations after the tools have been put into use.

The Master Mechanic, who is responsible for the Tool Room, estimates the amount by which it will be necessary to exceed these budgets, and explains the matter to the Vice President—Manufacturing.

The latter in turn explains it to the President, who is the executive responsible for the company's profits. Perhaps the President then consults with the Vice President—Sales, who informs him that delay in the date of introduction of the machine will seriously damage the morale of the distributing organization, because they have been told of the forthcoming new model. Conferences may follow with the Vice-President—Research and Engineering, who makes it clear that acceleration of parts design cannot be effected in his division.

Fur may fly as ways are sought to compensate for the failure of planning or performance, as the case may be. Let us assume in this instance, however, that the President reaches a decision to authorize the Manufacturing Division to exceed its budget by arranging with an outside tool shop to produce a portion of the tools required to put the item into production on schedule. The decision is transmitted to the Vice President—Manufacturing and thence to the Master Mechanic, who proceeds to carry it out. He exceeds his budget with full confidence that he is not only authorized to do so by his boss, but that his action fits into the framework of the budget control system. He also is aware that it has had proper consideration by all concerned and that it is in the best interest of the company.

It seems to me that you may well have here the difference between a confident, effective manager and one who is unsure of himself because he is hampered with doubts concerning the nature of the limitation placed upon his actions by an intangible thing called a budget. The significance of this is incalculable. With the responsibility for budget administration, you have in your hands the make-or-break of departmental management. I do not mean to imply that there are not other equally important factors—sound organization, for example—but it is quite clear that the art of getting the most inspired performance from men has, as one of its prime media of expression, the budget practice of the company.

### Planning Comes First

It is important that the parts played by the controller and the industrial engineer in this scheme of organized thinking be understood, but I should like to defer talking about it until we have considered the third law of budgeting which our company discovered in the search for knowledge in which it was perforce engaged. Stripped to its essentials, this canon says that budgeting is the expression of planning. Or, to put it another way, budgeting is the process of applying dollar requirements to an operating plan, piece by piece.

It goes back a long way, but I can remember when the word "planning" was never thought of in connection with the budget. The process we followed then consisted largely of estimating, for each expense account, how much more or less the forthcoming period would require than the figure for the immediate past period. Relatively little time was devoted to actually planning the operation, and, when subsequent comparisons were made of actual results with the budget, their value to management was proportionately diminished.

Just where in our history the planning idea was clothed with enough substance to make it effective in budgeting I do not know. Probably it was a gradual unfolding. In any case, we ultimately evolved a new approach.

If the department to be budgeted was a production department, for example, we asked its foreman to think more deeply. First we gave him as clear an idea as possible of the job he was to do, including the probable range of volumes he must be prepared to handle. Then we asked him for a flexible plan. How much actual labor time per standard direct labor hour? How much set-up and idle time? How much supervision? How much overtime and night shift time at various levels of operation? What percentage of material waste? What standards of maintenance? In other words, in terms of the operation itself, what is the plan for meeting the demands on the department?

The examples could be multiplied, of course, and the story is a familiar one to most of us. Yet it is surprising in how many places budgeting is thought of as a technique superimposed, rather than as the statement in dollars of a plan of operation.

### Company-Wide Planning

There is also a deeper phase of this line of reasoning that ultimately makes itself known to the budgeting pioneer. Not only must the individual departmental budget be well grounded in planning; to attain maximum fruition the

budget structure should rest on a foundation of planning which embraces every activity in the company.

We have hammered at this fourth principle until we now feel that it is accepted by our management at all levels. The methods of applying it will differ in individual situations, of course. In our company we plan, budget and control by means of what is known as a profit and loss forecast for a period of twelve months ahead, and a financial program for a three year period. The former is revised quarterly, the latter annually.

The profit and loss forecast is simply the ultimate statement, in figures, of coordinated planning carried out in great detail by all units of the business. It starts with a forecast of orders received for each product and for each major market. When this part of the plan is approved—and this is sometimes a major hurdle in itself—we move to the Manufacturing organization, where its Production Planning Department determines production quantities for the forecast period, as well as inventory quantities, with specific attention to leveling production over the period to avoid fluctuations in employment.

Responsibility for the prices applied to the quantities to be shipped rests with the Sales Division, although the President is the ultimate judge with respect to price levels. The Controller's Division then assembles all of these data and we now have a forecast of sales in units and dollars.

The Manufacturing Division furnishes us with all of the elements of the cost of sales figure—with the coordinating help of the Cost Department. This forecast includes standard costs and manufacturing variances, the latter in effect becoming a part of the planned cost of manufacturing.

To complete the picture, the other operating divisions of the company—the Purchasing, Research, Sales and Controller's Divisions—submit their budgets for the period. The general administration budget is prepared by the President, and the Controller prepares, subject to the President's approval, the budget of financial and other nonoperating items. Federal taxes on income are computed and we then have a complete profit and loss budget for the twelve month period. The entire process is repeated four times each year, providing each time a revision of forecast for nine months and a new forecast reaching three months ahead into the future.

The steps I have described sound simple, and they would be if we ignored the quality and characteristics of the estimates entering into this pro forma profit and loss statement. The fact is that each determination has its roots deep in the procedure which we call planning, and this fact transforms the simple into the complex.

To plan a year of operations is practically tantamount to going through the entire twelve months ahead of time. All decisions must be foreseen and made. People must be employed and their compensation determined—all on paper. Negotiations must be concluded and contracts executed. New facilities must be provided if they are needed. It is no mean gymnastic to perform this array of tasks mentally in advance.

Furthermore, all decisions by an administrative personnel organized in the manner of these times into divisional, departmental or sectional units must be coordinated. Manufacturing must provide the quantities of product for which Sales takes orders, and Purchasing must procure the materials required by Manufacturing. Even Research is reduced to some scheduling, despite the well known maxim that you cannot time-table invention. It has been done, within limits.

Out of this welter of soul-searching, in which each man's plan is tested a dozen times and ways, and its rough edges worn off through multiple collision with the plans of others, comes that which guides the business. The master plan has emerged. Each part of it, a controllable segment, fits into place. The translation of this creature into dollars and labor hours and units of product is known as the budget or forecast. When the outcome has at last earned the blessing of top management and the Board of Directors, it becomes the guiding instrument for action.

I have tried in this brief description of our planning to illustrate a truth which, as soon as we discovered it, changed forever our attitude toward budgeting. It is so simple that, like any natural law, it hardly seems worth repeating once it has been mastered—yet it is fundamental. It is that the plan comes first, and the budget is no more nor less than the statement of the plan in all its facets in the common language of dollars.

### Financial Programming

This leads to a fifth point, although, chronologically, I am now less clear as to the exact sequence in which these were discovered. I suspect they were unfolding simultaneously. In any event, this one stands out sharply defined from the others.

We found that we must broaden the base of our planning to include a financial program as well as an operating budget. This conclusion could hardly be said to have come out of the budgeting project itself. It stemmed more from the absolute necessity of knowing what our cash balance would be three years hence if we committed ourselves to a large building program. It stemmed also from the need to know how much long-term money to borrow.

In retrospect, however, the entire conception of financial programming in our company bore a very close affinity to operating planning. Every accountant is sensitive to the interplay between operating and capital items. For instance, added to the legitimate reasons for replacing old equipment is the temptation to reduce by such a course the charges for maintenance and repair which seem to crawl upward with each year of a machine's life. To carry the matter a step further, it is probable that an organization with the best kind of budget control for operating costs but lacking control of capital expenditures will spend capital money unwisely. Feeling the healthy downward pressure on costs that such a budget system generates, it may find itself unconsciously saying yes to questionable capital expenditures, simply because new equipment of modern design usually cuts current charges to operations.

Our first step to extricate us from this trap was a procedure for appropriation, review and approval of capital expenditures. The Board approved individually all items in excess of $20,000, the President items from $2,000 to $20,000, and the division heads items under $2,000. Many companies seem to have experimented with this type of scheme. Most of them I dare say have duplicated our frustrations with it. You are never quite sure you are doing just the right thing, even with a running total of approved projects to guide you.

Furthermore, and what was doubtless worse, there was never any reasonably reliable way of knowing how much we could afford to spend in total on the multitude of feasible sounding proposals which were always crowding in on us.

As I have said, the financial program, inspired by other needs, was taking shape meanwhile, and finally plugged the gap in our capital expenditure planning. It seems simple enough now, but it took quite a while for us to see that failure to plan completely will hinder the full expression of the planning idea in any segment of the company's affairs. To put it another way, the lack of a financial program, embracing capital expenditure planning undermines the program of operating budgeting.

### The Long-Range Planning Process

I do not mean to imply that we are a model of perfection in this field, but to round out this picture, I should like to describe briefly our approach to financial programming. The complete program is constructed each year and presented to our Board of Directors at its December meeting. It covers a period of three years. Interim revisions may be made, of course, if needed.

Each division of the company is asked to submit for this purpose its capital expenditure requirements for the period, although obviously the Manufacturing Division gets the lion's share. Requirements must be detailed, by individual machines and pieces of equipment, and must be accompanied by information as to the probable date on which the cash disbursement will be made, allowing for procurement time. This latter fact calls for careful discussion between the Manufacturing and Purchasing Divisions.

The Sales Division is asked to produce a long range forecast, which sets the

course to be followed with respect to products and volume. The Research Division is intimately connected with equipment needs for products to come. Nearly all of the operating departments of the company are involved in the process of thinking out the coming three years. Advance decisions are forced into being. The future of the company becomes a subject of searching thought. The eyes of the executive group and of many of their subordinates are turned to the horizon.

On this foundation, the Controller's staff continues to build. Estimates of inventories during the planning period are elicited from Manufacturing. Accounts receivable are estimated on the basis of the sales forecast. Earnings levels are provided by the President. Depreciation reserves are computed, current liabilities approximated, and we now have the skeleton of a pro forma balance sheet for a period of three future years.

Only the cash balances and borrowings remain to be determined, and the decisions in this area are given top level consideration by those responsible. The three year financial program then takes final shape and, after approval by President and Board, becomes a fundamental guide-post. It controls the balance sheet in much the same manner as that in which the operating budget controls the profit and loss statement.

Notice that we now have a control on capital expenditures at two levels. First, there is the list of individual items and projects which has been woven integrally into the over-all financial program. Second, and particularly applying to changes in planning occurring as the year progresses, there is the ceiling on total capital expenditures in the financial program itself. The modern planning and control principle is given full expression through all the diverse channels of corporate activity.

### False Measure of Success

Out of all of this potpourri of thoughts emerges a sixth point to make note of in establishing the budget atmosphere. The success of a budget cannot be measured by how close the actual result approximates it. How many times have we heard sales executives chortling over hitting a forecast almost "on the nose"? Offsetting variations in individual products, markets, and prices may have been numerous and wide, but if the total sales figure for the month was close to forecast, the bright light of success is shining.

I should like to advance the thought that to exceed the sales forecast may indicate either good performance or bad forecasting; that to fail to sell the forecast level may indicate either bad performance or bad forecasting; and that to be under, equal to or over forecast may indicate nothing significant whatever with respect to the quality of performance or of forecasting. The last statement, of course, implies the appearance of developments which the sales executive could not have been expected to anticipate at the time the forecast was made.

Let us suppose, for example, that a new item is to be introduced to the line on a specified date. Let us further assume that we have a seasoned Market Research Department, which has studied the market potential by means of field survey and other techniques, and that the outcome of this study is a forecast sale of 5,000 units in the forthcoming year.

During the first three months, however, competition unexpectedly hits the market with a brand new feature, which temporarily paralyzes our sales effort. After 1,000 of the units have been sold, the item is remanded to Research for intensive study directed toward overcoming competition's advantage.

Now here is an unforeseen and probably unforeseeable development, which turns the forecast topsy-turvy. How much weight should we give this happening in appraising the quality of our forecasting? I should say none at all. Let us turn our eyes to the future, change our plan and move ahead.

### Systematic Revision

In fact this little example points up the need for a systematic method of revision for the entire plan—budgets and forecasts included. For the past seven years we have insisted on this "new look" four times annually. During the early part of this period we were more or less constantly working under the illusion that as soon as things returned to normal once more, we could reduce these revisions at least to twice each year. Now we know better. "Normal" is never coming back. In fact, we are a little doubtful if it ever was here at all. In any case, the pace keeps accelerating, new developments impinge on us with the speed of lightning, and we are more and more conscious of the need to be alert to shift our planning with equivalent facility.

It is this very flexibility in our planning techniques which holds our sights on the future. Comparisons of past performance with forecast are useful only as they guide us in our planning for the future. To put it simply, they re-tell us wherein we have departed from our plan, thereby affording us experience in the planning art.

If the planning was ably done and the control machinery well designed, these deviations were known before they occurred, and were based on appraisals and decisions made in the light of ample information, and in an unhurried atmosphere.

The crux of this entire argument must be apparent by now. The importance of having a plan is to provide some forward thinking to guide our decisions and to tell us how we are coming out if we follow it. If the pre-decisions are sound and the planning is based on all the available facts and on careful reasoning, it is a good plan. Whether we follow it or decide to change it is a secondary consideration, providing the change is made in an orderly manner. The one sin that we cannot afford to commit is to operate without coordinated planning. We may as well drive a car on a dark road at night without headlights.

### A State of Mind

My seventh and final point concerns the attitude of all staff people concerned with budgeting. It is most natural for me to approach this phase of the subject from the standpoint of controllership, but I am reasonably sure that the same conclusions apply to industrial engineers, cost accountants or anyone else in a staff capacity having to do with budget administration. I am interested in seeing these people equipped with a philosophy which will enable them to motivate their operating associates toward a soundly planned, well controlled operation.

Properly speaking, a controller neither plans nor exercises control authority, except, of course, in the confines of his own department, where he is functioning as an administrator rather than as a controller. He does not plan for the company nor for any of its operating parts; his job is to see that the responsible executives do their own planning, and that they do it properly. He does not exercise control authority; he leaves this prerogative with those upon whom it has been conferred; his job is to see that they control their own operations.

The same advice may be given, of course, to cost accountants, budget men and other members of the controller's staff. Their task is never to censure, always to inform—never to veto, always to appraise—never to limit, always to support. Naturally, this group of men is looked to for a contribution to cost control, and the work they do in that direction is indispensable; but their entire effort should be directed toward providing the guide-posts by which the responsible operating supervision may be assisted to perform creditably. I should like you to be the judges of whether these comments apply also to industrial engineers, regardless of where they report in the organization structure.

We might sum up the matter by saying that your budgets are most successful when the staff budget man heeds the commandments we have been discussing. Budgets are most successful when he has enlisted the complete understanding and participation of top management in a planning and control effort which touches every phase of the operation. Budgets are most successful when the designated staff people provide the inspiration, the machinery and the teaching for this process, but refrain from usurping the slightest decision-making privilege conferred upon their associates.

It seems a little ethereal to say that budgeting is a state of mind, but this is a conclusion which we are all forced

(Continued on Page 23)

# LABOR PRODUCTIVITY AND INDUSTRIAL EFFICIENCY

**By Knut Holt,**

*Professor in Industrial Management, Norwegian Institute of Technology*

From being a word used only by economists, "productivity" is today a well known slogan in large parts of the world. The background for this rapidly growing interest in productivity is the great and generous aid given by the United States to assist the war stricken countries in order to help them to increase their national production.

Today it is generally recognized that the only way in which a nation in the long run can keep increasing the material standard of living for its population, is through a continuous rise in production per man hour.

The industrial engineer has played and will continue to play an important role in the efforts that must be made in order to increase the productivity within each individual enterprise. In this task, however, he cannot have increased production per man hour as his main short term objective—he must also consider the economical aspects of the suggestions and recommendation he makes.

Here is an area of partly conflicting views, and it is the purpose of this paper to examine closer some of the economical implications of productivity improvements.

**Definitions**

The word productivity — originally meaning the quotient between output and *one* of the input factors—is now used in a number of different ways. The most accepted meaning of productivity—used without further qualification — seems to be productivity of labor. In order to avoid confusion, this concept will here be called labor productivity. It can be defined as follows:

*Labor productivity is the quotient between the physical output in a period and the man-hours spent in order to obtain this output.*

Some authors are using the word productivity to indicate the relationship between output and *all* input-factors. The most accepted word for this concept, however, seems to be efficiency. This word will also be used in this paper and with the following definition:

*Efficiency is the quotient between the physical output in a period and the sum of all input factors spent in order to obtain this output.*

As the input factors are expressed in different physical units (hours, tons, kwh. etc.), they can not be added directly, but must first be converted to a common denominator. As such, a value unit will be used here, namely the dollar.

**Productivity and Capital Investment**

Productivity of labor can be increased in a number of different ways. One of the most important keys to high productivity is the application of modern high productive machinery and equipment. The gains in productivity achieved up to now are largely due to this factor and major future gains will also depend on technological improvements in basic processes and methods.

Productivity improvements based on the replacement of old equipment with new and modern types require capital investment and this creates additional costs. Although increased labor productivity usually will give lower labor cost per unit, the result may be that total cost per unit will increase and thus create a reduction in operating profits.

It is obvious that a private company, in the long run, must be able to make an output, the sale of which is large enough to cover the costs of all the input factors spent to get this output—preferably there should be a certain surplus. Competition also demands that the total cost necessary to achieve a certain output should be kept as low as possible.

In undertakings operated by the government the situation can be somewhat different. The products made or services rendered can be of such a nature that it, from a social point of view, is necessary to keep the undertakings going, even if the income is not large enough to cover all expenses. But even in this case it is of real importance to keep the financial support as low as possible, as the money can be considered to be taken away from other projects of social value.

Thus it is necessary both in private and government operated companies to get the output as large as possible in relation to total input—in other words the objective for the industrial engineer and plant management must be to obtain the greatest possible efficiency or lowest possible unit cost.

The demand for increased labor productivity and greatest possible efficiency will not always be in harmony. As long

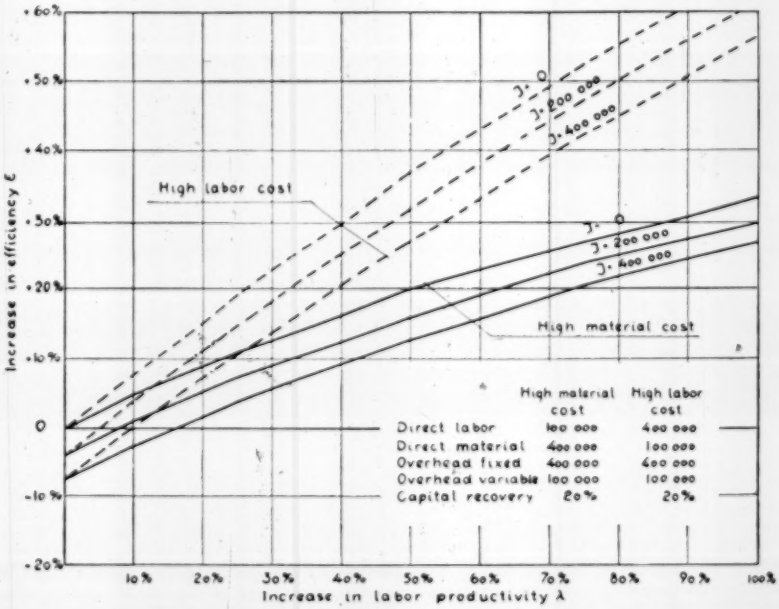


Fig 1. The relationship between capital investment, labor productivity and efficiency.

as the production in a plant can be increased by means that do not lead to an increase in any of the input factors, both labor productivity and efficiency will increase. If, however, the increase in labor productivity is due to a significant increase in one or more of the input factors — e.g., materials, capital, energy—the result may be lower efficiency and thereby increased unit cost.

This condition is particularly relevant to production increases obtained by the replacement of old with modern equipment. In as much as such replacements are one of the major sources for increased labor productivity, this paper will be limited to this aspect, although the same approach can easily be used for other input factors.

### The Model

From the discussion above it is clear that there must be some kind of relationship between labor productivity and efficiency. Here it will be attempted to establish this relationship through a mathematical model, based on an approach developed by *Gerber* for the study of the influence of labor productivity on net return on capital investment in his book "Die Rentabilitat der Produktivitatssteigerung," Vienna, 1952.

In order to simplify the presentation, the model will be developed for a company making only one product. Further it is assumed that there are no changes in the labor force, which means that increased labor productivity will be followed by a corresponding increase in output and material consumption.

The following symbols will be used:

$l$ - labor productivity in units per man hour
$h$ - increase in labor productivity in %
$e$ - efficiency in units per dollar
$\varepsilon$ - increase in efficiency in %
$N$ - number of units made per year
$C_L$ - direct labor cost in dollars per year
$C_M$ - direct material cost in dollars per year
$C_O$ - overhead in dollars per year
$C_{O_f}$ - fixed part of overhead
$C_{O_v}$ - variable part of overhead
$I$ - capital cost of new equipment in dollars
$c$ - capital recovery factor in %

The symbols will be used without index to indicate the period before a new investment in better equipment is undertaken, and with index for the period following. This gives:

Labor productivity after the investment:

$$l' = l(1+h) \qquad (1)$$

Output after investment:

$$N' = N(1+h) \qquad (2)$$

Direct material after investment:

$$C_M' = C_M(1+h) \qquad (3)$$

Overhead after investment:

$$C_O' = C_{O_f} + C_{O_v}(1+h) + cI \qquad (4)$$

Efficiency before investment:

$$e = \frac{N}{C_L + C_M + C_O} \qquad (5)$$

Efficiency after investment:

$$e' = e(1+\varepsilon) = \frac{N'}{C_L' + C_M' + C_O'} \qquad (6)$$

Combining (2)(3)(4) and (5) with (6) gives:

$$\varepsilon = \frac{(1+h)(C_L+C_M+C_O)}{C_L+C_M(1+h)+C_{O_f}+C_{O_v}(1+h)+cI} + 1$$

$$= \frac{C_L + C_M + C_O}{C_M+C_{O_v}+C_L + C_{O_f} + c\,I} + 1 \qquad (7)$$

$$\frac{}{1+h}$$

Having arrived at the model described by equation (7), the relationship between efficiency, labor productivity, capital investment and operating costs can now be analysed.

### Analysis

From the model it is immediately seen that an increase in labor productivity ($\lambda$) tends to increase efficiency ($\Sigma$). The capital investment (I) however, works in the opposite direction, and may if it is large enough lead to a decrease in efficiency. As there should be no decrease in efficiency as a result of capital investment, the maximum allowed investment can be determined by setting $\Sigma = 0$ in the model. Doing this gives:

$$I_{max} = \frac{h}{c}(C_L + C_{O_f}) \qquad (8)$$

From (8) it is seen that the maximum investment is not influenced by the cost of direct material. This means that companies with a high labor cost can profitably go to a higher investment than companies with a high material cost—assuming that other circumstances are equal.

In order to easily analyze the relationship, the mathematical model is presented graphically in Fig. 1 for two companies having the same total cost, but the one with a high labor cost and the other with a high material cost.

From the graphical presentation can be drawn the following conclusion which also can be deducted from the model:

1. Improvements that give increased efficiency will lead to higher labor productivity.
2. The precentual increase in efficiency will be smaller than the corresponding increase in labor productivity.
3. The increase in efficiency—at a given increase in labor productivity—will be greatest in companies with a high labor cost.
4. Improvements that give increased labor productivity without capital expenditure or increase in other input factors, will give increased efficiency.
5. Increased labor productivity obtained by investment in capital equipment may lead to reduced efficiency and thus to increased costs. The reduction in efficiency will be greatest in companies with a high material cost.

As stated before the model is based on the assumption that only one product is made. The same approach can, however, also be used when a number of products are made. This gives a more complicated model, but the same main conclusions can be drawn from it.

### Summary

Increased labor productivity is the fundamental requirement for an increased material standard of living. The productivity of the labor in a nation can in the long run only be increased by increasing productivity within the industrial enterprises in the nation. From a company point of view, however, output must be considered in relation to all input factors. Increased efficiency or lowered unit cost is therefore one of the main objectives for management in the individual plants.

Based on a simple mathematical model it is shown that there exists a definite relationship between efficiency and labor productivity. Whenever labor productivity is increased without capital expenditure or increase in other input factors, there will be a rise in efficiency. Large investments in new equipment may however lead to reduced efficiency or higher unit costs.

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# Book Reviews

*"Executive Leadership—An Appraisal of A Manager In Action*

by Chris Argyris, Harper & Brothers, New York, 1953, 139 pages, $2.50

This book is an absorbing case study of an industrial executive's relationships with his subordinates and superior officers. It describes in detail how these men handled the daily problems encountered in administering a unionized plant of nearly six hundred people. Incidents ranging from the most cooperative and harmonious to the most tense and frustrating are reported as they took place.

Unique in the literature of executive leadership, this book represents three points of view. First the author, as director of the study, makes an appraisal of the leader's behavior and its effects on the supervisors. Then the leader is given the opportunity to describe how he thinks he leads and his attitude toward this type of leadership. Finally, the supervisors report their reactions to the leader. From a synthesis of these three viewpoints, the author defines an ideal pattern of leadership.

This book will be of practical value not only to those who train and hire executives, but to every executive concerned with developing positive, effective qualities of leadership.

# INDUSTRIAL INVESTMENTS AND ENGINEER ECONOMY THEORY

By Ernest H. Weinwurm,
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Industrial investments have been widely recognized as a prime factor of business cycle fluctuations. The very large amounts earmarked for such investments in the postwar period have focused attention upon the principles and methods which are used in making decisions on such investments as compared with the theory of engineering economy which is concerned with this same type of problems. A survey of actual practices in an area on the West Coast was undertaken some time ago by the University of California, Berkeley.[1] The results of this survey should be of considerable interest to students of the field. Among the findings of the survey are the following:

1. Some of the executives making decisions on plant investments were not aware of engineering economy theory.
2. Most of those executives who had some acquaintance with the theory were reluctant or even opposed to its use for making decisions on actual investment problems.
3. Most of the companies surveyed did not use interest rates in their calculations but relied primarily on rather short pay-out periods.
4. Many of those who conducted economy studies were unfamiliar with compound interest methods and with considerations of the cost of capital under different conditions.
5. Even when economy studies were made with consideration of compound interest, they were given little attention by the decision-making executives who relied primarily on intangible and judgment factors.

Thus the survey revealed a definite discrepancy between the theory of engineering economy and the practice of decision making in regard to the problems of industrial investments. Such a situation certainly seems to call for an analysis of the causes as a prerequisite for narrowing the existing gap.

Most of the teachers and writers on engineering economy theory will be inclined to blame the industrial executives. For they take it for granted that the theory is correct and, therefore, those refusing to accept it are wrong. The authors of the survey report reflect this point of view in stating that

1. there is no real conflict between theory and practice and
2. we should adapt our practices to the theory.[2]

However, this may not exhaust the scope of the problem. The true causes may be more deep seated and in need of a more thorough investigation.

### Basic Concepts of Engineering Economy Theory

There is no agreed definition of Engineering Economy among the writers on the subject. For instance, Professor Fish, the first author of a book on "Engineering Economics" emphasized the investment concept as the fundamental issue after having first stressed the topic of economic selection.[3] Professor Grant, his successor at Stanford and the most widely recognized authority in the field, seems to sway back to the original viewpoint of Fish when he states that Engineering Economy is a comparison between alternatives whereby the differences are expressed in monetary terms and technical considerations are somewhat involved.[4] Though all the authors recognize that non-monetary (irreducible) data have to be taken into account, there is a tendency to concentrate upon those which can be expressed in quantitative monetary terms and thus represented in comparatively simple formulas.

Two concepts are particularly characteristic of current engineering economy theory. First, an effort to bring about *equivalence* among several alternative proposals as a prerequisite for decision making and, second, the peculiar application of the *time value of money* to attain such equivalence.* The time-value-of-money concept leads to the use of compound interest techniques for the purpose of getting equivalence of data which reflect different time values. This is usually done by computing the present worth of those data.[5] As a matter of fact, compound interest techniques have become such an important part of instruction in engineering economy theory that there is a wide-spread feeling that the two are a sort of siamese twins with one dependent on the other.[6]

Comparability is undoubtedly a primary prerequisite for making sound decisions among alternative projects which is the declared aim of engineering economy theory. However, it does not follow that the method of achieving time equivalence by means of compound interest computations is the only or the best method for attaining such comparability.

Incidentally, Professor Grant deals extensively with the short-comings of this method and emphasizes particularly the difficulty to make it meaningful to the average businessman.[7] But it seems that his position on this topic has gained much less acceptance than many of his other statements and does not reflect the general trend.

It may be worth noting that the definition of engineering economy as a comparison between alternatives with the differences expressed in money terms and technical considerations being involved does not present a clear distinction from the general problem of decision making which has been given so much attention of late. It is a technique of science of how to make proper and correct selections among different alternatives on the broadest scale.[8] Clarification of this point seems to be an urgent and important matter which should be given the significance which it certainly deserves.

### Model Building and Engineering Economy

The apparent antinomy between theory and practice under discussion should be looked upon as merely a part of a much wider problem which has gained prominence in connection with the expansion of operations research techniques in recent years. One of their essential features is the construction of scientific models. This has been a familiar technique in science, economics and other fields for a long time, but now has been expanded into industrial engineering and management as well on a substantial scale.

[1] "Plant Investments and Survey Results," Edward C. Keachie, Feliciano M. Gonzales and Robert J. Brown, *Journal of Industrial Engineering*, May 1954

[2] "Some Industrial Practices in Capital Goods Acquisition and Replacement," Paul T. Norton Jr., *Proceedings of Summer School and Conferences 1954 Engineering Economy Committee of The American Society for Engineering Education;* published by Stevens Institute of Technology, Hoboken ,N. J. (for an excellent and comprehensive discussion of this problem.)

[3] *Engineering Economics*, John Charles Lounsbury Fish, McGraw Hill Book Company, First edition 1915, second edition 1923.

[4] *Principles of Engineering Economy*, Eugene L. Grant, Ronald Press Co., Third Edition 1950, chapter 1

[5] Grant, ibid., chapter 3

*This makes the opposite practice as indicated by the survey a matter of particular significance.

[6] Discussion of Papers on "Some Industrial Practices in Capital Goods Acquisition and Replacement by Paul T. Norton Jr.," by Anatole R. Gruehr, *Proceedings of Summer School and Conference 1954* (see note 2)

[7] Grant, ibid., chapter 8

[8] *Design for Decision*, Irwin D. J. Bross, The Macmillan Company

Whenever these models are used for analysis and evaluation of actual facts and conditions, there is always the possibility of a gap developing between the functions and assumptions incorporated in the model and the actual conditions which it proposes to reflect and represent. Results derived from scientific analysis of the model may well turn out to be inapplicable and even misleading when an attempt is made to use them as a guide for making decisions for a set of conditions of a different type. This may be so in spite of the fact that the analysis of the model may be fully consistent in itself.

The history of economic theory provides numerous pertinent examples for the applications of conclusions derived from scientific models on actual conditions of a completely different kind. There is a danger that similar failures may occur as a result of applying the technique of model construction on problems of Industrial Engineering and business management.

The conflict brought out by the survey may be considered as such a discrepancy between a model constructed by engineering economy theory and its application on actual conditions which do not fit the model. This approach will be followed in the present paper. A few fundamental concepts will be discussed as a preliminary for a more comprehensive analysis to be undertaken later on.

### The Bond Model

The historical evolution of the model which was developed by engineering economy theory has been the subject of a recent study which coined the term "*bond model*" for the one currently used by the theory. This particular model had been widely applied on the evalution of bond yields where equivalence studies are of major significance.[9]

The bond model as used by financial analysts embodies a set of definite data such as issue or purchase price, interest rate terms of redemption, and others. These data are readily available for every type of bond in circulation. Therefore, all the computations made are based on definite quantitative data and not subject to any judgment factors. To purchase a quantity of bonds means investing a definite sum of money capital under well defined and known conditions. Once the bondholder has received his investment through the redemption of the bond as well as the interest and perhaps a premium, the investment cycle has been completed in accordance with the terms agreed upon and set forth in the original bond indenture. The only uncertainty is the possibility of a debtor's failure to meet his obligation. This risk factor is reflected in the issue (purchase) price and the interest rate of the bond. Under normal conditions it is of little significance.

The situation is similar for investments in bonds issued in connection with the financing of public works such as roads, bridges and other structures, if the redemption and interest payments are dependent on revenues collected for the use of those facilities (tolls, rentals, etc.). There is the risk that the revenue may be insufficient to meet the obligations. Guarantees by local authorities are often used to eliminate this risk and thus place the bonds on a level of equality with those of direct governmental obligations.

### Industrial Investments

Quite different conditions prevail in connection with the financing of industrial investments. Here there is no immediate or legal connection between financing and actual investment. This is true for both the raising and the repayment of the money capital. An industrial enterprise is not set up for a definite, limited period of time or for the completion of some particular objective as is a public works project. Once the capital has been invested, it may be tied up indefinitely until final liquidation of the enterprise. Funds becoming available from one particular project may be used for investment in another. On the other hand, a stockholder or bondholder who is in need of each or wants to switch his investment may sell his bonds or shares to someone else. There is no intention of liquidating an enterprise in order to redeem a bond issue on maturity.

Recent financial policies of the United States Steel Corporation may be referred to as an example of *actual* industrial practices in financing investments. The company had spent some two billion dollars for expansion purposes since the war, including improvement and replacement of plant and equipment. All of this capital had been provided for from internal sources such as retained earnings, depreciation, reduction of working capital and so on. In the summer of 1954, the company sold three hundred million dollars of bonds to replenish its working capital and bring it up to a level considered adequate by the management. These bonds were to be redeemed in ten equal annual installments. Obviously, these redemption terms have no relationship to the useful life of any of the assets acquired from the proceeds of the bond issue if such connection could be ascertained at all. They simply reflect the expectations of the management as to the cash funds available from year to year for bond retirements.

It can be clearly seen that the bond model which dominates engineering economy theory does not fit a situation which may be considered typical for industrial financing practices. Recommendations based on the theory which in turn is based on the bond model will merely confuse executives and make them distrust the whole theory of engineering economy as is clearly indicated by the results of the survey.

The formulas developed and used by engineering economy theory operate with two principle variables namely the life of the investment (return *of* the investment) and the interest rate applied for the compound interest computations (return *on* the investment). There is no agreed-upon procedure for determining the interest rate. In practice, it is set more or less arbitrarily with reference to some particular type of investment.[10]

The life of the investment in the context of engineering economy theory is an estimate of the time as will be required to return the invested capital to the investor (Professor Grant uses the term "cost of capital recovery"[11]). In the instances which fit the bond model, this time period was determined definitely and embodied in the terms of the borrowing agreement. But as far as industrial investments are concerned, there is nothing as definite. The capital recovery period has to be estimated. But such estimates will be subject to and influenced by many future developments which cannot be foreseen with any kind of definiteness. Thus it will be hardly more than an informed guess particularly if the period in question is expected to stretch over a substantial number of years. This situation has led to the use of very short life estimates (pay-off periods) as a means to reduce the risk factor involved in the uncertainty of the estimate.

There can be little doubt that the effect of using formulas based on compound interest computations is quite different for conditions which are similar to those incorporated in the bond model and those which are in accordance with industrial practices. What appears natural and sensible in one instance looses its meaning in the other. Engineering economy theory has failed to give adequate attention to this obvious distinction.

### The Capital Goods Model

It has become evident by now that the bond model is by no means representative of the methods and practices of industrial investments. Therefore, its use for the evaluation of those practices should be abandoned. It should be replaced by another model which will be tentatively called the "*capital goods model*" in consideration of the fact that its principal applications are in the field of investments in industrial capital goods (fixed assets).

The balance of this paper will discuss a number of topics and situations which may be helpful in developing the new type of model. This will not be an easy task, but a start should be made without delay regardless of difficulties to be expected.

1. Industrial investments, as mentioned before, neither have a life which can be definitely determined in advance in most

[9] "Aims and Contents of Engineering Economy," Arthur Lesser Jr., *Journal of Engineering Education*, January, 1954

[10] Grant, ibid., chapter 8 (on what is to be considered a "conservative" interest rate)

[11] Grant, ibid., chapter 7

instances nor are they subject to annual capital recovery in the sense that the capital will be actually returned to the investor or earmarked for the repayment of especially identified investments. The constant arguments between tax payers and the Internal Revenue Service about the "life" of assets proves this conclusively.

What is commonly termed "depreciation" is not such a return of capital, though this is widely claimed to be the case in the accounting literature. Depreciation is primarily a cost of production reflecting the current use of the facilities which are just as essential for the completion of the product as are material, parts and labor. Depreciation allowances are a cost of "capital recovery" not in the sense of being returned to the investor but as a means of maintaining the invested physical capital through keeping the facilities in good operating conditions in accordance with current industrial technology and practice.[12]

The confusion surrounding the concept of depreciation has strongly affected engineering economy theory. It has tended to adopt the formalistic concept of the accountant and tax collector which is so often in open conflict with actual technological conditions.

2. One of the effects of the present state of engineering economy theory and its inability to provide suitable measures for industrial investments is the widespread use of the so-called "pay-off period" concept as a guide for making industrial investment decisions, as was shown by the results of the survey. Pay-off is primarily a *cash concept*. It is concerned with the period of time required to return the cash invested in a project. This cash is expected to be provided for from increased cash revenues or the avoidance of cash disbursements. Thus no consideration of cost or income is originally involved.

But the pay-off concept has been used as a substitute for measuring income and return on investment as well. The result has been a strange mixture of cash and income viewpoints which has hardly contributed to a better understanding of the various problems involved. The weakness and inadequacy of the pay-off concept has been pointed out repeatedly in recent years.[13]

3. In order to make correct decisions among alternative projects, it is essential to present the relevant factors and data in such a manner that the advantages and disadvantages, to the extent that they can be foreseen, are clearly indicated. In this context, the equivalence concept of engineering economy theory has its useful applications as was pointed out before. However, its weak point is the over-emphasis on the time factor which was reflected in the widespread adoption of the bond model.

Business management has never adopted this approach which has such an important place in engineering economy theory. The general principles of equivalence in presenting the data reflecting alternatives as a prerequisite of decision making must be complied with in other ways. The writers referred to before as well as others have shown that this is not as simple a proposition as might be assumed from the formulas of engineering economy theory. It is a complex procedure which takes much time, effort and ingenuity to accomplish, if all the pertinent data, both monetary and non-monetary, shall be duly taken account of. Newly developed techniques of capital budgeting will be very helpful in working out suitable data for appropriate managerial decisions.

4. One major weakness of the time equivalence method is the averaging-out of fluctuations over the life of the investment. This is necessary to simplify the formula approach. But in fact those fluctuations may be quite significant from the viewpoint of managerial planning and control. Therefore, they should be clearly and fully indicated rather than lost in the averages.

Overemphasis on the capital recovery period is another disadvantage of that method. The period required to return the cash has little or nothing to do with the period during which the investment will remain a source of income. This latter period may be and should be much longer than the one of mere cash recovery. This point has been stressed by Joel Dean and his associates.

5. Engineering economy theory assumes the possibility of making separate and satisfactory cost and income computations for individual investment projects. This is a sound assumption for situations which are in accordance with the conditions of the bond model. But it is often impractical for industrial investments, for approval of one project will affect many other existing conditions in a plant or an enterprise. These can often not be predetermined correctly and neither expressed in definite quantitative terms. This is another reason why business men find engineering economy theory to be so very impractical and unrealistic. It fails to give a clear indication of the limitations of quantitative determinations which are essential for the computation of simpler formulas. In fact, these limitations should be clearly pointed out rather than hidden away and minimized.

6. Problems in engineering economy often show only small differences between the leading alternatives. But hardly any attention is given to the adequacy and reliability of the data the computations have been built upon. There may be considerable difficulties in collecting and interpreting data which are considered to be reliable, divergent opinions regarding the classification of accounts and transactions, and many other substantive questions.

Therefore, those in charge of preparing data and making proposals for decisions among alternatives should be familiar with the methods, problems and limitations of collecting, interpreting and using accounting and statistical data. Otherwise, grave misinterpretations of the scope of those data may be unavoidable.

7. Engineering economy theory with its concentration on quantitative data fails to give sufficient weight to non-quantitative factors which often are more important than the others in making sound decisions. Obviously, there are major problems in dealing with these factors and it is for this reason that they have been minimized. But such tactics will not lead toward a solution. Proper methods will have to be developed to take them into consideration as fully as possible. Operations research workers have to deal with similar difficulties with regard to non-quantitative data. This strengthens the need for a positive approach to this kind of problem.

8. A distinction should be made between the concepts of interest and return on investment. But engineering economy theory tends to identify the two terms.[14] The one of interest should be reserved for the creditor-debtor relationship; the bond model reflects this situation. Return on investment, on the other hand represents the compensation of the investor in a business enterprise (the owner vs. the creditor). Therefore, interest is usually a fixed rate while return on investment fluctuates in accordance with the success in operating an enterprise.

Return on investment may be subdivided and a portion may be classified as interest which is the rate obtainable from alternative investments. Another portion may represent the risk factor and a third the compensation for the operator of an enterprise if he is both investor and manager. This distinction is commonly made by economic theory but it is not a matter of major importance.

Return on investment is similar to the profit concept of the accountant which also lumps together the several subdivisions referred to above. Engineering economy theory puts great emphasis on the segregation of interest from the aggregate profit or return.[15] Again this is not a major issue but merely one of classification.

What needs to be emphasized is that return on investments is not a fixed but a variable data and, therefore, cannot

[12] "Depreciation Allowances and Production Costs," Ernest H. Weinwurm, *The Controller*, November, 1954

[13] *Dynamic Equipment Policy*, George Terborgh, McGraw Book Company; *Capital Budgeting*, Joel Dean, Columbia University Press; "Measuring the Productivity of Capital," Joel Dean, *Harvard Business Review*, January 1954

[14] Grant, ibid., chapter 3

[15] Grant, ibid., chapter 2

be estimated accurately. It is representative of the capital goods model whereas fixed interest reflects the bond model.

9. Determination of a proper rate of return is a complex problem. Companies which are using the concept of return on investment as a measure of managerial efficiency are familiar with these difficulties and have worked out solutions suitable to their own peculiar needs. Various factors have to be taken into account to determine a useful and practical return figure. In particular, the return required of new investments should have a proper relationship to that available from existing ones. Management seems often inclined to demand fancy return figures which fail to reflect rational consideration. The result may be to eliminate from approval projects which may offer a quite reasonable return. Even more important perhaps, such policies may bring into disrepute the whole concept of return on investment as a fair measure for both investment decisions and managerial ability.

10. In fact, the compound interest and present worth method like the payoff period concept have a definite bias against longer-term investments. The advantage of higher and longer earnings weighs only little in the computation of the present-worth alternatives particularly with higher interest rates. As a practical matter, each period of time stands for itself in the life of a corporation. The present worth concept, useful as it may be in comparing bond yields does not serve any constructive purpose when it is applied on industrial investments. Ten years from now, a million dollar profit will be just as valuable to the management of that date as is a million dollar profit to the present management. This fact is obscured and confused by the indiscriminate application of the compound interest and present worth concept. Since management planning has to consider ever longer periods as a result of technological and marketing conditions, this bias may have quite significant effects on planning decisions of the future until appropriate counter-measures are taken.

### Conclusion

It will hardly be possible to condense all the relevant data and considerations of the capital goods model into a simplified formula as has been accomplished for the bond model. Yet efforts to sacrifice complexities to the urge for simplification may lead to disappointing results.

The present methods of engineering economy theory will have to be confined to those areas where they can be applied successfully. There is still a wide field where the bond model can serve satisfactorily. But its use should not be extended beyond that area merely as a matter of convenience and routine.

As progress is made in developing the capital goods model, the existing gap between engineering economy theory and industrial practice will gradually be narrowed. Industrial management is alert for new techniques which will provide real help in making sound decisions on long term investments. Therefore, the demand exists and what is needed is the supply of a useful and practical theory. Once it is available, there will be no longer any complaints that industrial executives are disregarding the theory.

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## BUDGET

(Continued from Page 17)

eventually to acknowledge. It is an atmosphere and an attitude. It begins in the president's office (though the controller may have planted it there) and it reaches down through all the layers of the organization, until its laws are understood by the front-line supervisor, and even, to some extent, by the men and women we so easily refer to as "the workers."

Make no mistake—this state of mind is not one of niggardliness. It is not negative nor detrimental to progress. It is not one of pressure and friction, in which all are oppressed by a cruel philosophy of criticism in the effort to cut costs. All of these mistakes have been committed over and over in the development of this science.

Instead, the budget idea should invoke the voluntary self-discipline so necessary for accomplishment. It should promote the orderly consideration of problems when decisions can still be made ahead of time rather than in an atmosphere of crisis. It should help to fashion a structure of sound relationships, in which each manager or supervisor knows his duties, to whom he is responsible for their performance, and the importance of planning and control in carrying them out.

Based on the understanding and practice of good budget principle, there is no excuse for a budget system not making a surpassing contribution to the progress of any company. But we must keep always before us the fundamental that it is the human factor, properly evaluated and utilized, that makes a budget successful.

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# Book Reviews

*Group Cohesiveness in the Industrial Work Group"*

by Stanley E. Seashore; Survey Research Center Series No. 14, Institute for Social Research, University of Michigan, Ann Arbor, Michigan, 1954

Group cohesiveness as defined by the author is the attraction of the individual workers to the group or their resistance to leaving it. The investigation showed that members of small groups with high cohesiveness showed less anxiety and had more consistent production records. However, more consistent production was not necessarily better production. The attitude of the small group toward the company was the determining factor in the level of output. This is an interesting study for those who are concerned with the sociology of the industrial worker's behavior.


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# Incentive By Chance?

PART I

By Martin L. Smith

*Personnel Manager, The American Air Filter Company, Louisville, Kentucky*

This paper reviews the deficiencies of existing methods of industrial incentives, attempts to account for the deficiencies in terms of some behavior concepts, and proposes an untried method for encouraging greater individual production from industrial workers.

This new method, which is described in the latter portion of the paper, eliminates the problem of determination of "normal" production, and appears to avoid most of the psychological problems that go with conventional incentives. It is designed to capitalize on the attraction which games of chance hold for most people and to employ that appeal to reduce boredom and to invest the work operation itself with a value which it has not previously had.

### Time Study Is Not Scientific

All of the conventional incentive methods depend, with respect to any given operation, upon a definition of "normal" production. In the solution of this problem, Management typically employs one of several time-study techniques, the essentials of which include a breaking-down of the operation into its component elements, a series of timings of the elements and of the entire operation, and, finally, a judgment of the rate at which the subject was performing the operation.

The careful analysis of job elements and the painstaking, split-second timing of the elements tends to endow the time-study process with an air of scientific precision and authority. Unfortunately, the chain is no stronger than its weakest link, and that link—in this case the unscientific guess as to the operator's work pace—is quite weak.

### The "Reward" Formula

Once the question of a "normal" rate of production is settled (even if erroneously), it becomes possible to establish a relationship between the rate at which an individual produces and some type of reward factor. If, in an imaginary situation, it is "normal" to produce six pieces an hour, then one may expect 48 pieces to be produced in a normal day. If a worker is paid a dollar an hour for producing this "normal" quantity, the labor cost of each piece is almost seventeen cents.

Since the operation is not machine-paced and it is clearly evident that the operator is incurring no strain at all, Management concludes that he could easily complete more than six pieces per hour—perhaps even twelve per hour—with a little effort. How to procure these extra pieces?

Well, Management can agree to pay him fifteen cents for each piece instead of paying him an hourly rate. This price would cost the operator money if he continued to make six an hour, but would improve his earnings if he made seven, and would reward him abundantly if he should make twelve.

Or, they can say to him that whenever he has completed 48 pieces he has completed his day's task and is free to go home unless he would prefer to stay and turn out extra pieces for extra money. Thus, he can be rewarded with extra money or extra free time.

### Why Doesn't It Work?

"Why, oh why," so many disillusioned Managements have asked themselves, "doesn't he get busy and cash in on these rewards?"

Why, indeed? Why in the name of common sense should managements find it necessary to impose 'ceilings' on incentive earnings to their own disadvantage? Why should it be necessary to maintain a small standing army of time-study people and factory accountants in order to protect the trifling gains that do result from conventional incentives? After all, Management has gone to considerable trouble to make it possible for the employees to earn extra rewards by their own efforts, to Get Ahead in the best Horatio Alger tradition. Why does Management find that it is harvesting but a fraction of the unrealized production known to exist, and that it is beset, as well, with grievances, discontent, and endless new problems of negotiation?

### Theory Vs. Practice

Clearly, there is a discrepancy between the theory of industrial incentives and the practice. The Theory states, in effect: "The reason that employees do not work as hard as they can is that they do not share in the benefits that result from their hard work; therefore, given a fair and equitable opportunity to profit in direct proportion to the effort they expend, they can be expected to produce at the highest level they can comfortably sustain."

Alas, Experience reports, in effect: "Given a fair and equitable opportunity substantially to increase their earnings by increasing their efforts, the workers will not only fail to yield a significant portion of the effort of which they are capable, but will (a) devote abundant effort and ingenuity to devising ways of 'beating the system,' (b) will develop a litigious attitude toward any time study which does not have a comfortable margin of error in their favor, (c) will tend to develop new (and lower) ethical standards with respect to such practices as padding time cards, and accumulating banks of completed products, and (d) develop a hostile attitude toward the Management which (with the best of intentions) is making the increased rewards possible."

It often appears, as we reap the harvest, that we have sown not the seeds of a happy, busy, prospering work force but the teeth of the dragon.

Viewed in the light of human behavior, what have we done?

"You shall not pit one man against another!" thunders the Union.

"But we haven't," replies Management. All we've done is make it possible for the fellows to earn some extra money if they want to. Nobody says they have to."

"Everybody works hard in the factory," says the Union. "If one man is making $1.80 an hour, why shouldn't the other man who is working just as hard?" (Note the wording: "working just as hard," not "producing just as much.")

### Psychological Threats and Defenses

An incentive system threatens the average and below average members of the group (numerically the greatest segment). Because the attention of the entire program is focused on the production of the individual (and the program requires that it be carefully accounted), all but a few individuals in the shop are inevitably subject to unfavorable comparisons. The effects on behavior of such a long-continued reproach are well known to psychiatry.

First of all, it produces defensiveness. The normal response to an ego-damaging comparison is rationalization, which, in this instance, must take the form of attacks on the time-study (as being incompetent) or on the timestudy engineer (as being prejudiced or dishonest). The hostility against Management which crystallizes from the resentment against the cause of the intolerable comparisons, is essentially a by-product.

The second defense lies in the exercise of group control over individual production so as to limit or abolish the possibility of unfavorable comparisons. These controls are the so-called "ceilings."

Third, an individual who knows he cannot outproduce all other individuals can, by refusing to do his best, protect himself from the stark proof of his inferiority. He can supplement this defense by condemning the high producers as "meathounds" or "eager beavers."

Viewed in this light, the so-called "platform philosophy" of the CIO and other unions becomes more understandable. So, too, do the voluntary ceilings and deliberately 'loose' prices with which managements attempt to stave off the consequences of mass hurt feetings. One must choose, it seems, between peace and production.

### Boredom Hurts Worst

But the primary indictment of not only incentive methods but of factory life itself is on a charge of boredom. Rarely does the service required of a factory employee in return for his wage demand more than a series of habitual motor responses. In many cases, for him to take an interest in his job might only serve to lessen his efficiency by disturbing the well established motor habits which do his work. Little wonder, then, that, unless he has no imagination, he takes every opportunity to relieve his boredom with minor physical ailments, grievances, endless machine readjustments, minor breakdowns, horseplay, and the rest.

In a piece work incentive system, after he has satisfied his curiosity about how much money he can make, the employee has an intriguing game with many opportunities for matching his wits against management. 'Beating the system' serves well as a device for absorbing his attention and interest.

A truism which can bear stating because its significance is so often overlooked is that most factory employees do not work in factories because they are interested in what goes on there; they work because of necessity, and they work in factories because factories usually offer the easiest answer to untrained, uneducated, unskilled men with a living to make.

Human nature being what it is, which is to say that man having the nerves and glands he does, modern industry has worked itself into something of a fix, incentively speaking. Industrial efficiency and productivity have been best served by making all operations as simple and uniform as possible. The productivity of the individual, depending heavily upon his enthusiasm for what he does, has suffered correspondingly.

### Why Is He Bored?

It can be said of the unskilled and semi-skilled factory worker that as a consequence of the series of developments which began with the industrial revolution and ended with the highly automatic production line, that:

1. He has lost the satisfactions attendant on craft membership.
2. He has lost nearly all opportunity to exercise judgment or imagination on his job.
3. He has lost nearly all possibility of achievement on his job.
4. His chances for earning individual recognition, except as a disciplinary problem, have steadily diminished.
5. His need for the approval of his social group has come to depend on his union for satisfaction since there is almost no other provision for it.
6. There is no constructive aspect of his job which is capable of absorbing his interest, even though an incentive system of some type may exist.

In short, he is unable to find enough satisfaction in his skill, his job, his achievements, his company, or his individuality to preserve his morale at a satisfactorily high level.

### The Production Lottery

The scheme proposed in the following paragraphs is not primarily an incentive method. It is intended to offer the worker an activity in which he can participate, and which will both reward him economically and distract his attention from the tedium of his job. The increased production, so far as the plan itself is concerned, is a by-product, and yet it is the expectation of the author that the plan will do a far more effective job as a production incentive than any of the existing incentive plans.

Any worker who makes a product or does some operation in the making of a product tends to perform a cycle again and again. His value as a worker can be expressed as a ratio of the number of times he completes this cycle (or piece or operation) to the period of time for which he is paid. The essential aim of any incentive method is to cause him to complete more cycles (or pieces or operations) in a given period than he did before.

*If the cycle itself (or piece or operation) can acquire a positive value to the worker himself exclusive of the wage he is paid for it (as a chip to a poker player, for example)*, under circumstances which do not exhort him to work harder and which do not primarily emphasize his production and compare it to the production of others, it may be that we have gotten around some of the difficulties inherent in conventional incentives.

In the case of our hypothetical worker who produced six pieces per hour under somewhat leisurely circumstances, it is a simple matter to calculate how much additional reward we can offer him for extra pieces that he might produce. If he should double his production, we can afford to pay him almost two weeks wages for one week of work.

Supposing, however, that the additional reward money is not spread evenly over all of the pieces he might produce, but rather attached to certain of the pieces or cycles as lump sum rewards. In this case, if he could be relied upon to produce 480 pieces in one week instead of 240, 8 pieces out of the whole two weeks' production might each carry a special $5 reward. The worker, of course, would not know which pieces were the rewarding pieces.

### 'Chance' Is The Important Feature

The significant feature is that the worker would not be "rewarded" for an accomplishment of his own. His reward would be purely a function of chance.

Let's complicate our hypothetical case, and assume that we have ten workers performing the particular operation at about the same rate. Then we have 2400 pieces being equal to one week's production, 4800 pieces equal to two weeks' production, and we can afford to have 80 prizes of $5 each. Now we have a new element in the situation, and this is the one on which our increased production depends.

Under the laws of chance, our individual worker can expect over a period of time to average 8 prizes per week or one-tenth of the total available rewards. However, by increasing his production, he can improve his chances to share in an even larger percentage of the prizes.

In the long run, he will receive that portion of the prize money which is equal to the percentage of the total production which he personally completes. If he does not increase his production while the other workers do, his chances will shrink proportionately.

### No Deal Has Been Made

Meanwhile, he is being paid his regular rate for producing his six pieces per hour. No incentive bargain has been made with him, no high level income rate has been guaranteed him (either in fact or by implication). Even if he protects his chances, there will be weeks of little or no reward and weeks of heavy reward. There has been no time study of his job. His earning rate is not being openly compared with the other nine workers.

If he chooses to, he is at liberty to disregard the whole project and plod along at his six per hour. It will take some doing, however, for the appeal is the appeal of the slot machine or the turn of the next card. It is insidious and damnably hard to resist. If you hire a man to play a slot machine for you, provide as many nickels as he is willing to use, and allow him to keep any winnings the machine will yield, will his work pace be fast or slow?

### What Does It Take?

What are the conditions required for the operation of such a system?

First of all, it is necessary to be able to identify each cycle (or piece or operation) by job number, order number, or other system.

Second, separate systems must be set up for each group of similar workers, with the size and incidence of rewards separately calculated for each. Simultaneously, care should be exercised to make sure that the members of all groups have approximately equal opportunity.

Third, the selecting of the lucky numbers and the preservation of their secrecy must be absolutely foolproof. If necessary, the function should be handled by an outside organization.

Fourth, there should be an Inspection-Cashier Center for each group. In order to protect quality, some arrangement should be made under which most of a prize would be lost to the worker if his piece could not pass inspection. Upon completion of his piece, he would have to take it to the Center where it would be inspected and the identifying number compared to the numbers on the secret list of Winning Numbers. For the greatest effect, he should immediately receive his winnings in cash from the Cashier.

Fifth, there should be a complete lack of emphasis on the production aspects. If the plan works, it will be because the appeal is irrestible and not because the company wants more production. Sooner or later, the boys will figure out the company's angle, but, it is hoped, the appeal of the system will have had its effect by that time.

So far as the author knows, this approach has never been tried and there is no experience by which its potentialities can be evaluated. Its results are purely a matter of speculation. But, it looks like it should work.

### It's a Gamble

The management that tries it will be running the risk that the funds invested as prizes will be lost if the program doesn't have the anticipated effect. It will have gone to a good deal of trouble and disarranged a lot of its production organization, all for nothing if the program fails.

But if it works, they'll be in clover.

## AUTOMATION

(Continued from Page 13)

created capital surpluses which are partly employed in activity which led to further accumulation of wealth. Cumulative benefits have tended to accrue to those firms with excess capital. Automation, too, promises to reward the wealthier firms.

Although the rate and extent of unionization probably will not decline directly as a result of automation, there will undoubtedly continue to be a relative expansion of employment in the service activities, a large proportion of which have been resistant to union growth in the past. While there is still considerable room for organization of production workers in the economy, this shift in the employment pattern suggests a possible expansion of areas which are difficult to organize. For example, total employment has risen considerably since 1948, but employment in the increasingly automatic oil refining industry (which is highly unionized) has fallen from 147,000 to 137,000 since that time, although refinery production rose 22%. Referring to the decrease in production workers and the great increase in engineers and technicians in the steel industry, David McDonald, President of the CIO Steel Workers Union, said "We'll have to organize them into the steel union or we will have a smaller union." [13]

An additional consequence of automation suggested by Richard L. Meier seems worthy of comment. He states that "raw materials and intermediates with fewer 'non-linear' properties will substitute for those used at present. This means a greater emphasis upon the rise of electric power, gases, liquids, and pure compounds, with corresponding loss of importance of solids, crude mixtures, and natural products." [14]

The reasoning behind this statement is that the first-named properties are more adaptable to the flow of automatic processes. However, this may be only a temporary or an early consequence. As automation develops, some of the "non-linear" properties may be utilized more fully as the processes and machinery themselves are redesigned.

Automatic computers increase the amount of knowledge, the accuracy of information, and the speed with which it is obtainable, thus giving management a much clearer picture of its overall operation. By making knowledge of the consequences of alternative courses of action readily available, the businessman of the future will behave more rationally than in the past. Collective bargaining and product pricing will be based on a greater volume of accurate information so that areas of controversy will be narrowed and conflicts based on misunderstandings of facts will decline.

It has been argued in this paper that automation will increase the concentration of market power and capital. These trends are at variance with the maintenance of a competitive economic system in the usual definition of this term. However, there is one aspect of automation which threatens one of the traditional bases of monopoly. This is the information-gathering and handling aspect and its effects on ignorance, particularly of costs. Some of the failure of market competition to operate effectively in the past has been due to the fact that knowledge of alternatives has been inadequate. Nevertheless, opponents of big business should not look for assistance in this quarter. It appears that the expensiveness of the computers will limit their purchase, at the outset, to large firms with greater resources than their smaller competitors. It will be possible for a small firm to rent a computer or to purchase a machine in conjunction with several other companies and share its usage. However, programming remains as a large problem of the firm. In addition, the small amount of time allotted a firm under these circumstances will deny to the concern the mastery of the machine and the high level of performance that the sole owner should find possible.

In conclusion, the final judgment of automation must be based on the degree to which its benefits are made available to the public. The CIO and the AFL have openly endorsed automation but are insistent that the benefits of the greatly increased productivity be shared by consumers and workers. Most informed businessmen share this view. As Norbert Wiener has observed, "If man is to continue to exist, he must not be an afterthought of business." [15]

[13] Quoted in the **CIO News**, Sept. 27, 1954, p. 2.
[14] Richard L. Meier, "Automation in the American Society," unpublished manuscript.
[15] Norbert Wiener, **The Human Use of Human Beings**, Doubleday, 1954.

# Book Reviews

*"The Human Enterprise Process and Its Administration"*

University of Alabama Press, University, Alabama, 1954, 232 pages, $4.50

The author approaches administration as a part of the overall human enterprise process which includes the larger steps of conceiving, administering, and utilizing the enterprises. He analyzes the process into a series of common steps and shows the interlacing and interdependent relationships which affect the operation and success of human enterprises. The book provides a conceptual setting in which administration is oriented and in which the bearings of psychology, sociology, anthropology, scientific management, and other social sciences are developed.

*"The Language of Social Research"*

edited by Paul F. Lazarsfeld and Morris Rosenberg, The Free Press, Glencoe, Illinois, 1955, 590 pages, $6.75

The reviewer is of the opinion that all Industrial Engineers should appreciate the importance of the social sciences as an integral part of the Industrial Engineering problem. As the sub-title of this book indicates (A Reader in the Methodology of Social Research) methodology is the main theme. Although aimed at the professional social scientist and student, the material will be of great benefit to the Industrial Engineer who desires broadening his understanding and approach to the man-materials-machine relationship.

# THE TALE OF A COW

**Chapter I**

Let us suppose that I am the owner of a cow. The purpose of a cow is to produce milk. If you turn the creature into the pasture and allow her to eat grass she will produce many quarts of lacteal fluid. The process consists of eating grass, transmuting it into milk, removing the milk from the udder. However, you are infected with he system disease. You cease to be interested in milk. You hire inspectors to count the number and measure the height of the blades of grass eaten by your cow. You count the number of steps she takes in the pasture. You time the number of occasions upon which she looks over the fence and test the volume of sound produced when she moos. Then you employ a bookkeeper to record these items, and various persons to make out forms for the guidance of the bookkeeper. At the end of the year you have a vast and entertaining volume of information, but you have added so greatly to the cost of your operation by sysematizing in this manner that you lose money on every quart of milk you sell. This, of course, is exceedingly modern and in accord with business practice, but you find yourself compelled to sell your cow to pay your overhead.

**Chapter II**

Since you no longer produce and sell milk, you discharge your cow hands. This leaves you with no applied direct labor, but $10 a month overhead in space rented to store the cow's records. Your bookkeeper tells you that this rental makes your overhead rate infinity (ten divided by zero is infinity) and that you can reduce overhead tremendously—from infinity to zero—if only you get rid of the records. You give them to the farmer who purchased the cow. He does not know that your data are worthless, so he accepts the whole truck load.

He can not read, so he employs a scientist to help him learn what is in the records. Fortunately, you kept meticulous records; on analyzing them, the farmer's scientist learns that many things simultaneously affect how many quarts of transmuted lacteal fluid the cow can produce. The scientist, however, is bitten with a different disease—a strong psychological tendency toward optimization, compounded with an irrational passion for dispassionate rationality in seeking facts on productivity. In brief, he was looking for the high point on the milk production curve that corresponds to the low (sag) point on the udder.

By suitable analysis the scientist discovers from your data the number of blades of grass per day to feed the cow to get optimum milk production. Of course, for the convenience of the cow and the cow hand, the scientist translates this number into the number of pitchforks full. From your data on height of the grass, he learns the height (or maturity) of the grass at which it should be mowed for optimum utilization of the cultivated lands and production of milk. Your data on the number of steps the cow had taken yield to the scientist excellent information on the optimum percent of the time she should be roaming (exercising) in the pasture or quiet in her stall. Your records on where she had looked over the fence most frequently and mooed with the greatest gusto gives the scientist clues as to what grass is most palatable, while also nutritious. This increases her protein intake and butterfat output.

In no time at all the farmer has the cow producing so much milk that even with an expensive, non-transmutive (he did not personally transmute even one drop of the lacteal fluid) scientist on the overhead payroll, the unit cost of milk was greatly reduced. He then asks the scientist to study if he should expand his herd and how rapidly. In that study he also finds the optimum amount to reduce milk prices so as to make profits soar and stay at their maximum.

As the size of the udders, the herd and the profits grow, the farmer is so impressed with the scientific method he has the scientist set up a regular scientific business research group to look into all phases of the business and to advise him how to manage it more profitably. This new research leads to more profit-making discoveries that are not at all obvious and quite unexpected even to this experienced and seasoned farmer. The scientist discovers that many managerial problems even of the cow business are so intricate that only by scientific methods can an optimum course of action be found. For example, he finds that mathematical computing methods are necessary to obtain the minimum cost diet (food mix) that still provides required nutrition, to determine the shortest routes for his fleet of new delivery trucks, to determine the optimum amount and mix of dairy products to carry in his optimally located warehouses, to select the most profitable mix of butter, milk and other dairy products to make from a given batch of raw milk, to find the least cost daily work schedule and amount of equipment to purchase, to determine the most productive and profitable crop rotation plan for the cultivated lands, to compute what products should be sold now and what should be held for expected price changes, to determine the optimum balance between size of the herd, milk processing facilities, delivery fleet, and market potential. There are, naturally, other problems being solved scientifically, but they are too numerous to list here. Indeed, the farmer's customers also now are too numerous to list and the problems too large to solve manually, so he handles these jobs with the electronic data system the scientist determined was optimal for the job.

Of course, the farmer's overhead rate, with all this scientific research, now is sky high but he does not mind. He is in business to maximize profits and not to minimize overhead costs. This, of course, is not very modern and not at all in accord with business practice, but it does pay for more trips to Florida for the farmer and his scientist, but not for you and your bookkeeper.

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# Book Reviews

*"An Evaluation of Analytical Techniques of Engineering Economy"*

Proceedings of the ASEE Engineering Economy Committee, 1954 Summer School, edited by Arthur Lesser, Jr., Stevens Institute of Technology, Hoboken, New Jersey, 166 pages (out of print)

All engineers are concerned with engineering economy which was defined by Art Lesser as "the best economic use of resources, both material and human, at the engineering level." Unfortunately, the published material on engineering economy is spread widely and sparsely throughout the literature. In addition, much valuable work is in unpublished company manuals and procedures. The purpose of the summer school was to review and publish the advances in knowledge and analytic techniques in engineering economy over the past ten years.

Many excellent papers are included in the proceedings. Billy Goetz and Fred Westfield ably started off the session with a discussion of the contributions of economics to engineering economy. Alex Rathe and Ernest Weinwurm covered the difficult relationship with accounting very well. Jack Mitten and Lloyd Knowler brought out the usefulness of statistics in many engineering economy problems.

Two of the pioneers of engineering economy, Eugene Grant and Paul Norton, discussed the theory and practice of engineering economy in its present state. The relation of operations research and engineering economy was brought out by Jack Mitten and Paul Randolph. Other papers discussed the economic design of consumer goods, appraisal of war facilities, and the teaching of engineering economy to engineering students.

The program and papers are excellent reading for those interested in engineering economy. In addition to the papers, the proceedings contain a considerable amount of discussion on the papers and the general subject. The work is a valuable contribution to the profession of engineering and, we hope, a preview of future valuable contributions to the field of engineering economy.

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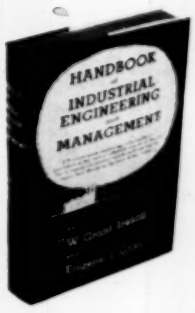


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